[inside]

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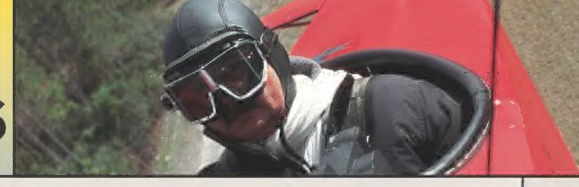

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(PAGE 48)

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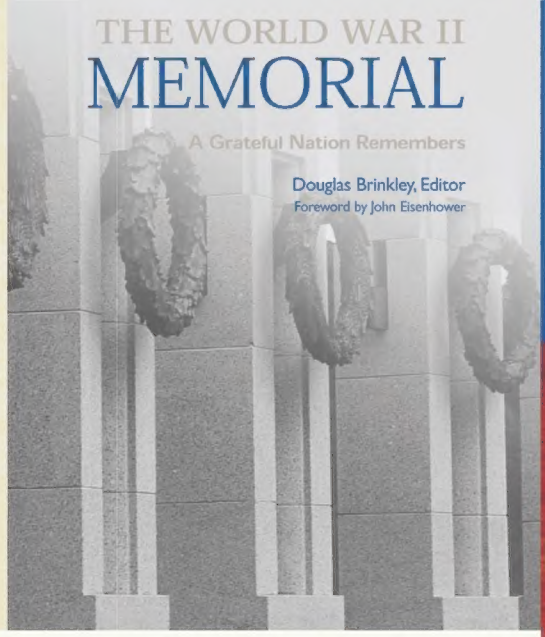

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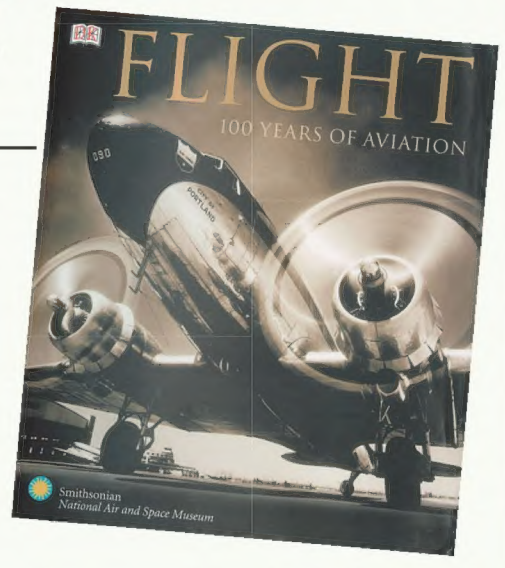

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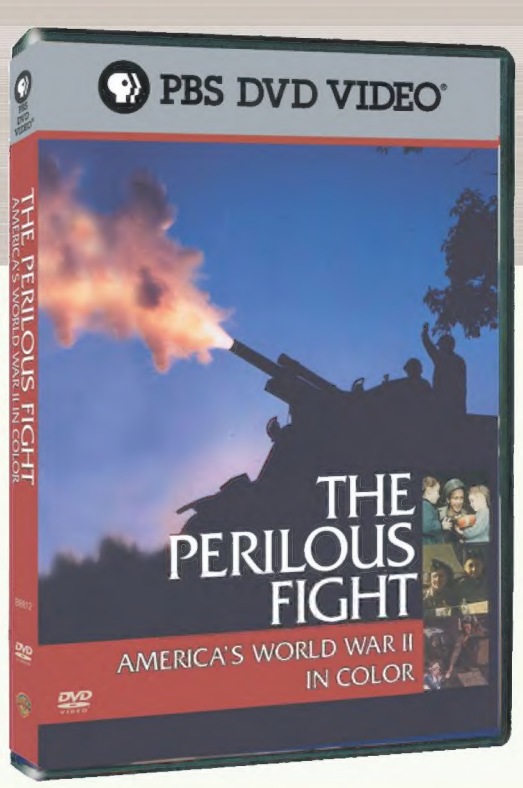

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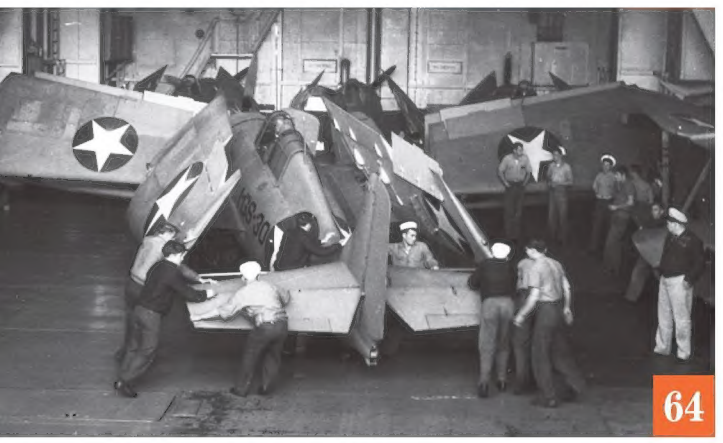
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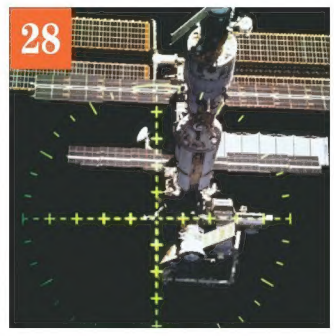
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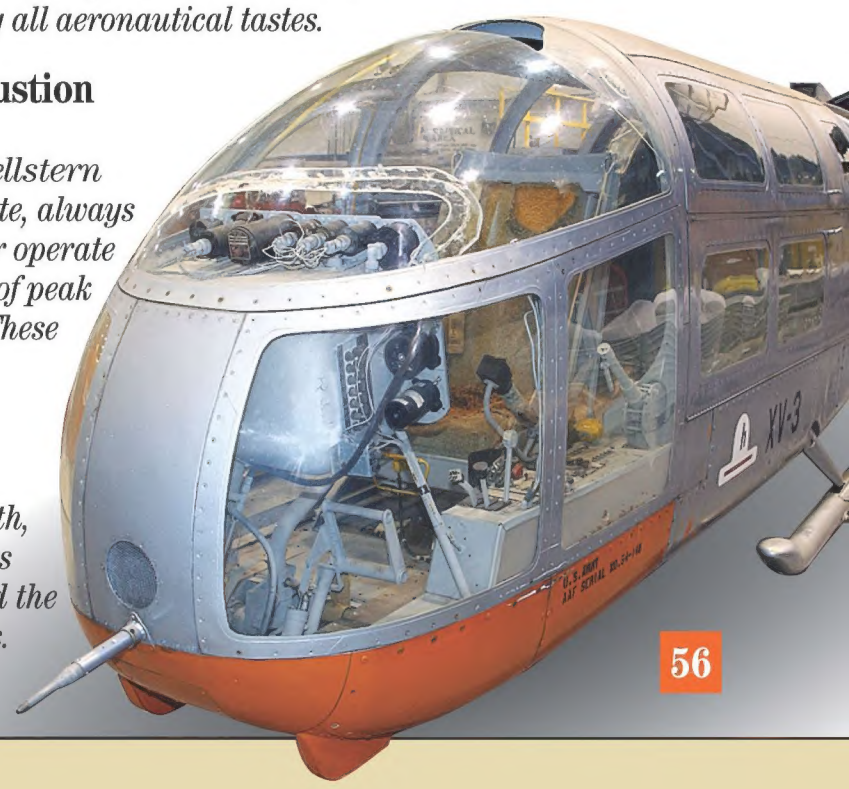

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Cover:
Chad Slattery's signature portrait of the long-lived Douglas A-4 Skyhawk frames a classic aircraft—one that cast a long shadow over 20th century air combat.

DEPARTMENTS

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The First Space Shuttle

A team of restoration specialists and volunteers swarms around a huge black-and-white bird at the center of the James S. McDonnell Space Hangar at the National Air and Space Museum's Steven F. Udvar-Hazy Center in northern Virginia. The center of attention is the space shuttle *Enterprise*, the first orbiter to roll out of the assembly plant in 1976 and the only one that has never flown in space. *Enterprise* was not equipped for space flight because it was used as a test vehicle to evaluate the shuttle's approach and landing performance.

Originally meant to be refitted to follow *Columbia* into space after performing a series of atmospheric flight tests and vibration and fit checks on the ground, *Enterprise* was withdrawn when NASA decided to fly *Challenger* instead. Today, *Enterprise* is the only survivor of the first three sister ships that inaugurated operations of reusable vehicles for space transportation in the early 1980s.

NASA transferred *Enterprise* to the Museum in 1985 after proudly putting the craft on display at the 1983 Paris Air Show and the 1984 World's Fair in New Orleans. Since then, the test vehicle has been in storage, awaiting a proper venue to return to public view. Now we have that opportunity.

Enterprise has not been idle in retirement. NASA engineering teams have visited the vehicle 11 times in the past 17 years to inspect it or to temporarily remove components for testing and analysis. Over the years, they have borrowed the landing gear and parts of an elevon for tests. They have removed several feet of cable and taken samples of plastic and rubber materials to determine the effects of aging. And last year they borrowed the main landing gear doors and portions of the wing leading edges for use in the *Columbia* accident analysis.

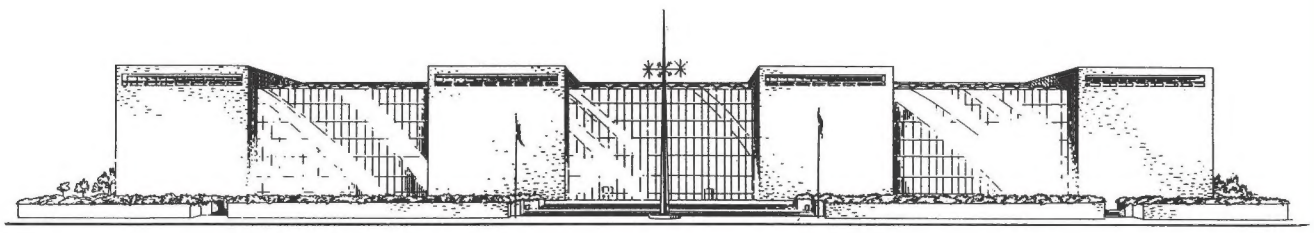
Because *Enterprise* is the oldest shuttle and the one with the least wear and tear, it remains a valuable asset for the nation's space program. Knowledge gleaned from it can help to improve the three shuttles still in the operational fleet. Some parts of the vehicle, such as the payload bay doors, are designated as flight spares and could be used on another shuttle if the need arises.

The first shuttle is still in excellent condition, but it acquired a coat of dust in storage, and it is shedding some paint on its payload bay doors. The Museum's team is giving it a good sponge bath and a fresh coat of paint to return the vehicle to its as-delivered condition.

Visitors to the Udvar-Hazy Center can stand at the hangar doorway and watch this fascinating work in progress. By the end of this year, when the space hangar opens, they will be able to walk around the orbiter to appreciate its size and distinctive features. We plan to build another hangar right next door that is dedicated to restoration, where visitors will be able to observe our specialists at work preserving a variety of aircraft, rockets, spacecraft, and other artifacts.

We are working hard to preserve *Enterprise* today so that it will be available for future engineers, scientists, historians—and curious visitors—to study and enjoy.

—J.R. Dailey is the director of the National Air and Space Museum.



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LETTERS

Haven't We Tried This Before?

"Retro Rocketeers" (Apr./May 2004) failed to mention that around 1991, the Assured Crew Return Vehicle (ACRV) project office at NASA's Johnson Space Center in Houston looked into using a variation of the Apollo vehicle as an emergency return vehicle for the then-unbuilt space station. We had two contractors on board (Rockwell and Lockheed), and both were looking at capsules, with Rockwell's design resembling a scaled-up Apollo. But no one outside of our office was particularly interested, so our office disappeared.

Dave Eichblatt
Houston, Texas

James Oberg's "Retro Rocketeers" and his earlier "Pod People" (Oct./Nov. 2003), in which I was quoted, both deal with vehicles for making emergency escapes from the International Space Station, and both clearly point out that NASA still has not come to grips with its future program requirements and how to satisfy them.

NASA is looking for a single solution to (1) the near-term problem of providing an escape system for more than three ISS crew members, and (2) the need for a crew exploration vehicle (CEV) for moon missions, and presumably the need to later grow that vehicle for a manned Mars mission. By looking for one solution, NASA is going down the same disastrous path that has caused the cancellation of its last three attempts to replace the space shuttle while providing a vehicle for crew return from the ISS. Again, the agency has been biting off more than it can chew.

If NASA completely divorced the two, as I and others have proposed, the agency would stand a better chance of achieving all its goals. I have argued that the lifeboats needed for each manned module of the ISS should have a large, unsupported land and/or sea landing footprint, and that they should thus be relatively unsophisticated winged vehicles. These vehicles would be analogous to an oceanliner's lifeboats; i.e., their use would make success probable but not certain. Because we really don't expect emergencies on the ISS, we shouldn't employ a sophisticated, high-priced CEV in a standby mode to provide this capability. Besides, we now have two gruesome examples of highly sophisticated reentry vehicles that did not make it.

In lieu of following its usual practice—coming up with a huge in-house effort to produce a specific design—NASA should formulate general performance specifications, give them to contractors, and ask for preliminary system designs. Then the agency should choose two or three concepts with great potential and contract with the companies that produced them for more-detailed designs.

So long as NASA carries the baggage of past designs, it cannot hope for optimum, timely, and affordable solutions to its problems.

R.F. Brodsky
Redondo Beach, California

The February 1960 issue of *Mechanics Illustrated* has a concept for a "Lifeboat for Spaceships," designed by a Frank Tinsley, that has the same operational profile as the Apollo; the reentry is virtually identical, including landing in the ocean.

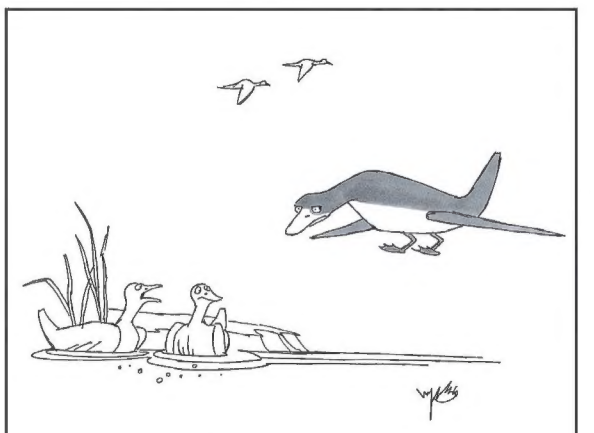
More proof that what goes around, comes around.

Mel Goddard
Brampton, Ontario, Canada

Over-Vaunted Vulcans

"God Save the Vulcan!" (Dec. 2003/Jan. 2004), referring to the five "Black Buck" raids made during the 1982 war in the Falklands, states: "The Vulcans, each one packed with 21 1,000-pound bombs, effectively cratered the Argentines' runway." As a member of the steering committee for the Secretary of the Navy's study of the Falklands conflict, I take issue with that. The U.S. Navy report *Lessons of the Falklands* (1983) states that those Vulcan sorties "had virtually no impact" on Port Stanley Airfield, which continued operating until the last day of the war.

Norman Polmar
Alexandria, Virginia



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A Peaceful Postwar Life

One of the QT-2s described in "Night Stalkers" (Apr./May 2004) was purchased from the government and converted back to a Schweizer 2-32 by the late Bruce Miller of Boulder, Colorado. The glider currently gives rides in Boulder for Mile High Gliding. It even has what appears to be bullet hole patches on the underside of the fuselage. It is one of my favorite gliders to fly, and I have given many hundreds of rides in it.

Patrick Doyle
Boulder, Colorado

The Arizona-China Connection

"French Lessons" (Feb./Mar. 2004) brought to mind another little-known international training alliance during World War II. We had Chinese students come to Luke Field in Arizona for advanced training in the AT-6. Instructors at Luke also gave the Chinese training in the P-40 Warhawk. The students were very anxious to fly that aircraft, for at the time, the U.S. Flying Tigers were in the news for flying P-40s to defend China against the Japanese. For the Chinese, going home as P-40 pilots would have been heaven.

I remember teaching a few of these students. We did have interpreters for the ground briefings, and one in the control tower when the students were in the air. I also remember that we had to be very careful about chewing them out, because we could not cause the Chinese to lose face with their fellow students.

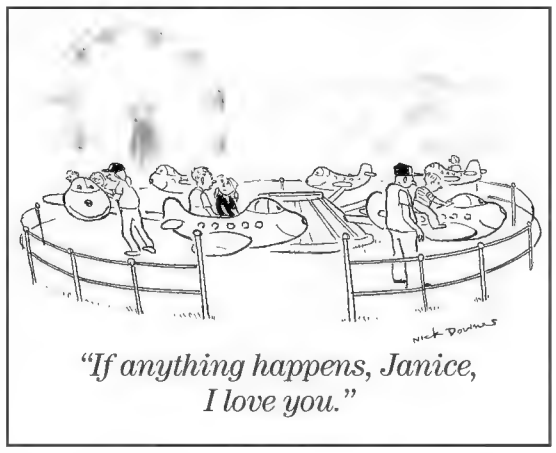
Col. Leroy C. Felton
U.S. Air Force (ret.)
Parkland, Florida

The Old Rainmaker

"New Job for an Old Tanker" (Soundings, Apr./May 2004) reports on a modified KC-135 being used to spray water and ice on the F/A-22. The chief engineer is quoted as saying: "The Raptor was the first aircraft to use our rain and ice tanker for test."

Now, as a young airplane enthusiast, I lived near the Royal Air Force base Brize Norton, in Oxfordshire, United Kingdom, which was then as now a major transport base. I distinctly remember that in the late 1960s or very early 1970s, a KC-135 was deployed to the base (from Edwards Air Force Base in California, according to the region's plane spotters). The local paper reported that the tanker's purpose was to carry out icing checks on the Concorde, which at the time was undergoing flight testing at nearby RAF Fairford.

John Pumfrey
Bloomingdale, Illinois



"If anything happens, Janice, I love you."

Airshow Schedule Changes

Since the publication of our airshow schedule ("Jump Into the Airshow Season!," Apr./May 2004), we've learned of several changes and additions:

Oregon The Hillsboro Air Show will be held on August 14 and 15;

Ohio The Cleveland National Airshow will be held on September 4 through 6;

New York The Iqaluit Air Show is in Nunavut Territory, Canada, not in New York. This error originated with the International Council of Air Shows and thus has been duplicated in other airshow schedules.

Readers planning to attend airshows should confirm the dates and locations with the venues or sponsoring organizations, as changes can occur throughout the show season.

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WARNING: May cause film lovers to drool, have bouts of ecstasy and go completely gaga.

Consider this your first warning — the new Canon EOS ELAN 7N/7NE is here. The film camera that gives photographers the speed, accuracy and reliability they've been craving.

The EOS ELAN 7N/7NE has the fastest autofocus in its class.* The new backlit display and Canon's exclusive Whisper Drive technology are built into its luxurious metal exterior, taking your photography to the next level.

The ELAN 7N/7NE also features high-speed, 4fps continuous shooting, 1/4000th sec top shutter speed and 11 shooting modes which, along with its 13 custom functions, make it unusually responsive. In fact, its 7-point wide area autofocus uses AF technology similar to the Canon EOS-1v and EOS-3, allowing you to track a moving subject with astonishing accuracy. EYE CONTROL

And the ELAN 7NE's exclusive Eye Control system reads your eye movements to pick the focus point automatically as you scan the scene, giving you a level of control unseen in other cameras in this class.

For fast, accurate control under the most difficult lighting conditions, the ELAN 7N/7NE features 35-zone evaluative metering, new distance-based E-TTL II flash metering and is fully compatible with all EOS accessories and EF lenses.

The extraordinary ELAN 7N/7NE. Incredibly fast. Remarkably sophisticated. Handle with care.

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Kilroy Was Here

Shrouded by willow, hazel, and hawthorn bushes, the remains of more than 120 U.S. 8th and 9th Army Air Force bases are scattered across East Anglia and Bedfordshire in the United Kingdom. Some of the buildings have been converted to workshops, pigsties, barns, poultry sheds, and grain stores, and some house still-vibrant wall paintings done by U.S. airmen. They were done in artist's oils, aircraft dope, or whatever paint, pencil, or crayon came to the hands of servicemen stationed at the bases after 1942. Despite 50 years of neglect, the pinup girls, bombers, emblems, and cartoons have survived in all their romantic, bawdy vigor. There are even signatures and lists of missions flown recorded on the ceilings in the soot from Zippo lighters.

In 1987, Peter Dyer, then a regular visitor to the abandoned U.S. base at Bottisham, home to many murals, met John Green, the landowner. Green wanted to safely remove the art before the imminent clearing of the site for redevelopment. Within a few months, Dyer had organized the removal of nine works, some weighing up to half a ton, with the assistance of a backhoe borrowed from a local farmer and help from like-minded acquaintances. The group formed the Eighth Wall Art Conservation Society, which has been instrumental in the removal and restoration or preservation *in situ* of many more paintings.

EWACS' biggest project has been the removal of a 1.5-ton painting, which depicts a B-17 amid bursting flak, from a debriefing room at the Podington base. "When we first went to view it," recalls Dyer, "there were two huge sows living under the picture. We wonder if the heat from the pigs' bodies helped preserve it." Once the brickwork had been secured within a frame of steel girders, it was removed and trucked to the Imperial War Museum at Duxford, restored by EWACS member Heinz Bosowitz, and put on permanent display. "We discovered that Staff Sergeant George Walschmidt, a ball turret gunner, was 19 years old when he did the painting in 1945," Bosowitz says. "We wrote to him as soon as we began the restoration and later learned that he had died from a heart attack 24 hours after learning that his painting had been saved for posterity." Another American artist, Jack Loman, painted some of the best surviving works in an enlisted men's lounge at Shipdham, Norfolk. His paintings, mostly calendar girls executed in the glamorous Vargas style, are still in remarkable condition, considering that the building has been unroofed for years. "I bought the paint in 1943 at an art store," he says. "Just regular artist's oil paints. It's amazing they've survived."

Around Christmas 1940, Royal Air Force ground gunner Robert Hofton, billeted at the Fowlmere airfield, prepared the barn his group occupied for a dance. He painted a three- by six-foot mural of gold RAF wings against an azure sky, with Spitfires and Allied fighters in formation, and added a German bomber

DAVID HIGGS/TEPA

An Eighth Air Force 92nd Bomb Group B-17 adorned the wall of a World War II military base hut in rural England (above) that later became a pigsty. A conservation group removed the art to safety in 1989. In what was a restroom at another base, an artist depicted the 392nd Bomb Group in action (left). Many of these types of paintings have been rescued from ruin.

UPDATE

Confirmed: St.-Ex's Lockheed

The remnants of a World War II reconnaissance aircraft found in 230 feet of water off the coast of Marseille in 2000 have been identified as parts of Antoine de Saint-Exupéry's Lockheed F-5B, which vanished on July 31, 1944 ("Fishing for Saint-Ex," Apr./May 2001). Diver Luc Vanrell had retrieved pieces unique to the F-5B (a modified P-38) after a bracelet with St.-Exupéry's name on it turned up in a trawl net in the same area. Various French government agencies, acting on the wishes of the author's descendants, prohibited further exploration until last October, when a government-contracted salvage team brought up pieces with numbers that correlate with the serial number of St.-Exupéry's airplane: 42-68223.

in flames, its pilot suspended from a parachute. "We were attacked once or twice, but I never got to fire a shot in anger," says Hofton, now 92. "I can honestly say that the painting was about the most useful thing I ever did during the war. I took a couple of days doing it, with camouflage paint mixed with hundred-octane aviation fuel."

EWACS members volunteer time and expertise to save the paintings most at risk. "It's to preserve the memory of men who were here today and gone tomorrow," says Dyer. "These men looked at these pictures, then flew off on a mission, and some were either killed or ended up in a POW camp. To save these paintings is to teach the children of today what men did for them all those years ago."

—David Higgs

Old Bombers, New Tricks

NASA is using an aging fleet of research aircraft—including retired B-57 bombers, a T-38 jet trainer, and the venerable UH-1 helicopter—to help get the space shuttle safely off the ground. A team at Johnson Space Center in Houston and Marshall Space Flight Center in Huntsville, Alabama, is developing a package of imaging sensors to potentially track the shuttle from liftoff to solid rocket booster separation—2.5 minutes into the flight—to detect any debris that might damage the vehicle during launch. (NASA is also adding cameras to the external tank, the solid rocket boosters, and the orbiter.)

"The film camera failed during the *Columbia* launch, and the backup was just a regular video camera, but the resolution on it was not good enough to see much," says Rodney Grubbs, program manager for the WB-57 Ascent Video Experiment. "Nobody could say with any confidence what, if anything, had struck the shuttle during liftoff."

WAVE will place pods of sensors on a pair of NASA's WB-57s. "The WB-57 is sort of like a U-2 on steroids," says Andrew Roberts, WB-57 program manager. "We can fly to a very high altitude and stay there." The former bomber will zoom up to about 65,000 feet. "We'll fly both WB-57s about 14 miles away from the shuttle and have the pods trained on both sides of the shuttle during liftoff," Roberts says. The WAVE sensors include a high-definition television camera, a wide field-of-view camera, and an infrared camera. "The infrared gives us the ability to see another part of the spectrum so that we can detect it in the visible," says Grubbs. "If something falls off the shuttle and can't be seen or doesn't reflect visible light, then perhaps we can detect the heat or 'see' it in the infrared."

In developing WAVE, NASA turned to the Army for help. The Army uses a "Fat Boy" pod, built by Southern Research Institute, to test missile sensors that its contractors supply. NASA filled the gimballed Fat Boy pod with imaging devices, and in February engineers ran tests at Marshall, with a UH-1 helicopter standing in for a WB-57 and a T-38 mimicking the shuttle at liftoff. The T-38 flew by the UH-1, which carried Fat Boy on its side, at 330 mph and 500 feet off the ground. "We calculated the speed and trajectory of the T-38 and where the helicopter was going to have to be to approximate flight conditions of a

NASA

The Martin B-57 was used early in the Vietnam War and for high-altitude reconnaissance missions over Russia and China. NASA has used WB-57s, primarily for atmospheric research, since the late 1960s; now it is enlisting its fleet in a test program to capture images of the space shuttle as it launches. The goal: spot any debris that could damage the vehicle.

WORK IN PROGRESS

Production Line

Herbert Tischler's Texas Airplane Factory, at Meacham Airport, northwest of Fort Worth, Texas, specializes in full-scale reproductions of vintage military aircraft. The TAF's latest contract, the manufacture of four airworthy World War II Nakajima Ki-43-IIIa Hayabusa radial-engine fighters, is its most challenging assignment yet.

The single-seat Hayabusa, more commonly known by the Allied code name Oscar, was a compact, highly maneuverable army combatant comparable to its better-known Japanese navy stable mate, the Mitsubishi A6M Zero. With nearly 6,000 of three major variants built by the end of the war, the Ki-43 shouldered much of the air combat responsibility often attributed solely to the Zero, and was also used for suicide attacks. Today, fewer than 10 complete aircraft survive, mostly in museums.

The first of the TAF Hayabusas is nearing its first flight after four years of work. Reverse-engineered from severely deteriorated parts—mostly fuselages and wings—of several Hayabusas recovered from the northern section of Japan's Kuril island chain by warbird collector Douglas Champlin of Nevada, the TAF aircraft are as authentic as contemporary construction requirements and available historical references allow. Tischler says only a very small percentage of the aircraft's parts are

JAY MILLER

A Texas company is cranking out Hayabusa reproductions.

original. Upgrades include Pratt & Whitney R-1830 Twin Wasp radials from DC-3s in place of the original Nakajima Ha-115 radials, and disc brakes in lieu of drum brakes.

Collectors, including Champlin, have dibs on two of the reproductions. The other two can be had for about $1.5 million each.

—Jay Miller

shuttle," says Grubbs. "We flew the helicopter at 2,000 feet and slightly less than two miles away from the target, the T-38." The pilot then pulled the trainer into a 45-degree climb to mimic a shuttle liftoff. The results of the test flights are under study. "The Air Force is going to help us with the contract with Southern Research Institute to actually build the gimbal if we get approval [to produce WAVE]," Grubbs says.

—Shelby G. Spires

Australia Gets the Point

The airfield at Point Cook in Melbourne, Australia, one of the world's oldest continuously operating airports, has been saved from a possible carve-up by private enterprise. "Point Cook will be retained in public ownership with the airfield and majority of the land leased for 49 years to a National Aviation Museum Trust," notes Fran Bailey, Parliamentary Secretary to the Minister for Defence. The announcement coincided with a February 29 airshow at the former military training facility. The show, attended by 25,000 air enthusiasts, celebrated the 90th anniversary of the first flight made at Point Cook, that of a Bristol Boxkite on March 1, 1914.

Bailey says the National Aviation Museum Trust at Point Cook will manage on-site aviation activities for educational, recreational, and commercial purposes, oversee development of a National Aviation Museum, and preserve heritage buildings. "This decision means that Australia as a nation is beginning to seriously rediscover its rich military and civil aviation heritage," says Mark Pilkington, chairman of the Point Cook Preservation Action Group.

The site of the first flying school in Australia, Point Cook is also the birthplace of the continent's military aviation services. The Army's Australian Flying Corps first organized here in 1913, an event followed by the establishment of the Australian Naval Air Service and the Royal Australian Air Force in 1921. Point Cook was also the departure point for the first south-north crossing of the Australian mainland (1919), the first circumnavigation of Australia (1924), and the first nonstop east-west aerial crossing of the mainland (by Charles Kingsford Smith in 1928).

—Don Darbyshire

DON DARBYSHIRE COLLECTION

RAAF

Then: Point Cook in 1925, hosting U.S. Navy Vought floatplanes (above) from USS Richmond.... *And now: A Sopwith Pup replica overflies the area, hearkening back to the years when the Royal Australian Air Force based a dozen or so Pups at Point Cook.*

Charting China

Unlike the sparse instrument charts used by commercial pilots, which depict only radio airways and navigational aids, Visual Flight Rules sectional charts are colorful landmark maps, packed solid with such ground details as land elevations, cell phone towers, towns, bodies of water, racetracks, and roads (see "The Art of the Chart," Oct./Nov. 1999). Nearly every nation has sectional charts, and China, where it has only recently become legal for individuals to own airplanes, is about to join the ranks. At last count there were only 554 private airplanes in China—0.26 percent of the U.S. total—but it's a start.

As far as landmarks, a pilot can't miss the Great Wall. And at the moment, all of China's airspace is under "positive control," meaning that pilots are always under Instrument Flight Rules. Nonetheless, the government decided its burgeoning class of private pilots will need sectional charts to find their way around. Late last year, after China asked for assistance, the Federal Aviation Adminstration's National Aeronautical Charting Office sent George Sempeles, a senior aeronautical cartographer, to China to help produce the first Chinese sectionals.

"They had only a small idea of what is involved to create this series of charts," he says. Sempeles taught the engineers about data extraction and compilation, and about charting major rivers, roads, drainage, and electrical lines, to name just a few. "One of the deficiencies they have is an incomplete accounting of all man-made obstructions," he says. On the other hand, they have photography from Landsat, NASA's family of ground-

imaging satellites, as well as help from U.S. Department of Defense maps of various Chinese cities.

"I took unclassified DoD charts and constructed a sample [aeronautical] chart of Shenyang, and I did the same thing for Beijing, just to show them what the product would look like," Sempeles says. "They were impressed how close we came to reality."

While the two nations are about the same size, China will be contained in 32 sectional charts, compared with 54 for the contiguous United States. One big reason: The entire mountainous region of Tibet is simply too high for private aircraft to traverse. And all of China contains but 168 airports, compared with nearly 15,000 U.S. airstrips. Also, between 75 and 80 percent of the country's airspace is off-limits to civilian aircraft, while just a small portion of U.S. airspace is so reserved.

Sempeles expects the first chart to come off the press in a couple of years, with the entire series finished by 2015. As for the 4,500-mile Great Wall (which, contrary to urban legend, cannot be seen from the moon), Sempeles says it's likely to span six charts.

—Phil Scott

Bag an Asteroid, Get Cash

Before he became famous as the hobbit Frodo in the *Lord of the Rings* trilogy, Elijah Wood starred in the 1998 movie *Deep Impact* as 14-year-old astronomy buff Leo, who discovers a killer comet heading to Earth. Also that year, the movie *Armageddon* dramatized the same question: What could we do if an asteroid has our name on it?

For one thing, we need more and better advance information, says U.S. Representative Dana Rohrabacher, chairman of the House Science Committee's Space and Aeronautics Subcommittee. In early March the House of Representatives passed H.R. 912, a bill Rohrabacher introduced to encourage amateur astronomers like Leo to discover and track near-Earth objects.

H.R. 912, also called The Charles 'Pete' Conrad Astronomy Awards Act, honors the late astronaut, a veteran of four space flights and the third man to walk on the moon. It authorizes NASA's administrator to make two $3,000 awards annually based on the recommendations of the Smithsonian Astrophysical Observatory's Minor Planet Center.

Three grand might not seem much of a reward for saving the planet, but you don't necessarily have to find a killer asteroid or comet to win. The awards will go to any U.S. citizen or permanent resident who, as an amateur astronomer or group of same, either discovers the "intrinsically brightest near-Earth asteroid" or makes "the greatest contribution to the Minor Planet Center's mission of cataloguing near-Earth asteroids." The bill defines an amateur as "an individual whose employer does not provide any funding, payment, or compensation to the individual for the observation of asteroids and other celestial bodies." Only 70 percent of the estimated 1,000 near-Earth asteroids with diameters of one kilometer (0.6 mile) or more have been discovered and catalogued.

A few weeks before H.R. 912 passed, Rohrabacher was the keynote speaker at the American Institute of Aeronautics and Astronautics conference on Planetary Defense. Referring to a scientist who said that the odds of an asteroid hitting Earth compared to those of being dealt a royal flush in Las Vegas, Rohrabacher said, "I have been dealt a royal flush in Vegas." He added, "We need to get people looking up."

—Richard Sassaman

UPDATE

The Sounds of Silence

Schweizer Aircraft was at press time poised to fly its latest ultra-quiet surveillance aircraft, the RU-38B, which, says company president Paul Schweizer, is "undetectable at 2,000 feet" ("Night Stalkers," Apr./May 2004). Schweizer has not divulged the name of his U.S. government customer, but he notes that the SA 2-37B, the new aircraft's predecessor, serves in "every place the USA is operating." The propellers on the twin-turboprop RU-38B can turn as slowly as 1,000 rpm; the aft engine is shut down in flight. Engine exhaust passes over the wing to reduce infrared signature.

SCHWEIZER

Hush, Hush, Sweet Schweizer

WATER WINGS

...And There's Room for 15 More Inside!

South East Asian Airlines has restored a Dornier Do 24 flying boat and offers it for luxury service to resorts in the Philippines. Iren Dornier, the commuter airline's founder and the grandson of German aircraft designer Claudius Dornier, retrieved the Dornier 24 ATT from the Deutsches Museum in Munich, Germany, last year and set about adding leather seats and turbine engines and converting it to an amphibian with the addition of landing gear. He plans to retrace the 1929 around-the-world route of the Dornier Do-X, a massive 10-engine flying boat, before starting local service. "The Dornier Do-X had a telephone on board and passengers smoked Havana cigars," Dornier says. "This is the same luxurious feel the aircraft will have." The Do 24s, some 200 of which were built in the 1930s and '40s, were used for marine rescue and transport.

SEAIR

Flightstyles of the Rich and Famous: A tricked-out Dornier serves the A-list.

Sixty Minutes Over Iraq

There were two stars center stage at the National Air and Space Museum on the evening of March 24: U.S. Air Force Captain Kim Campbell and the crippled A-10 she flew to safety after being hit by enemy fire over Baghdad.

One of just 50 female fighter pilots in the U.S. Air Force, Campbell was at the Museum to give a talk about her combat experience on the morning of April 7, 2003. Known by her call sign, "Killer Chick," or just "KC," Campbell was flying with the 75th Fighter Squadron, 23rd Fighter Group, to provide close air support for U.S. soldiers pinned down on the west side of the Tigris River. "The Iraqis were lobbing rockets from the east side of the river," she recalled.

The Fairchild A-10 Thunderbolt II, which Campbell called "an amazing airplane," is designed to get low. It's armed with a 30-mm Gatling gun, and the pilot is protected by a titanium-armor-plated cockpit. To prevent fires, the fuel tanks are filled with foam. "[The A-10] has two reliable engines and can run fine on just one," says Campbell. "It's designed to take hits."

Good thing.

As Campbell fired her last round of rockets over enemy troops, she "felt and heard a loud explosion in the back of my aircraft and knew I had been hit by enemy fire."

Her flight leader, Lieutenant Colonel Richard Turner, pulled up alongside her and saw that the A-10's rear fuselage was pockmarked and that a football-size chunk had been torn out of the leading edge of the right horizontal stabilizer. The A-10 had lost its hydraulic system, which the pilot uses to raise and lower the landing gear, apply brakes, and move the control surfaces on the wings and tail.

Campbell had two choices: Stay with the jet and try to land or eject.

During flight training, A-10 pilots are given a checklist describing how to control the aircraft manually in case the hydraulic system fails, but they never actually practice manual flight control. "The instructions say to try a manual landing only under ideal conditions. Not sure what that means," Campbell quipped, and the crowd laughed. Campbell, a 1997 graduate of the U.S. Air Force Academy, moves and talks like a confident athlete with an air of military politeness. During the question-and-answer session that followed her talk, she always addressed the questioner with a respectful "sir" or "ma'am."

USAF

Captain Kim Campbell inspects the damage to the horizontal stabilizer on her A-10 Thunderbolt, which took enemy fire during a mission over Baghdad.

Campbell's right engine had sustained shrapnel damage, but it was still running, and since Campbell could control her aircraft's pitch manually, she decided to make a run for her base in Kuwait. When the landing gear came down, she figured she had a reasonable chance, even though she knew well the stories of three pilots who had attempted manual landings in A-10s during Desert Storm in 1991. One pilot was killed, the other crashed but survived, and the third was successful. "My odds weren't great," said Campbell.

At this point in the talk, a large screen behind the stage began to show video footage from inside Campbell's A-10 as she coaxed the aircraft in for a landing. The audience fell silent and Campbell herself knew the clip needed no voiceover. The shaky gray image, which included the crosshairs of a viewfinder, leaned first to the right, then to the left, while the runway rose up in a rush. Suddenly all movement stopped and the audience realized that Campbell had brought the airplane to a full stop. They cheered.

"I felt such an incredible sense of relief when I hit the ground," said Campbell of the hour-long flight back to base. "The crash recovery team was there and the landing crew.

As Captain Campbell fired her last round of rockets over enemy troops, she felt and heard a loud explosion in the back of her A-10 Thunderbolt, and she knew she had been hit by enemy fire.

Later, the squadron's comments about my landing meant so much to me. I must say so myself that it was one of the best I've ever done."

In a telephone conversation a few days after the lecture, Campbell's father, Chuck Reed, an Air Force Academy graduate himself (class of 1970) and currently a city councilman in San Jose, California, revealed that his daughter was an average kid through middle school, "playing soccer and doing cheerleading and things. I think the *Challenger* explosion knocked her off course. She was amazed that people would take such risks for things more important than themselves. She began to think beyond herself. After that she became very self-directed and wanted to go to the Air Force."

Campbell herself was not too forthcoming when asked during the Q-and-A session why she chose to become a fighter pilot. She did say that there were about 30 pilots in her class, including four women, but she was the only female to choose the A-10. "When you graduate, you choose your aircraft based on your class rank," Campbell's father explained. "There [are] only a limited number of fighter slots—I think three. She graduated high enough to pick one of those spots, so obviously she did very well in pilot training."

After her close call in Iraq, Campbell phoned her parents, but wasn't allowed to tell them she'd been hit, only that she was all right. "She just kept reassuring us that the A-10 is very durable," says Reed. "The next day some friends of mine were circulating some photographs of an A-10 that had been shot up over Baghdad. They couldn't believe that it had landed safely. *Hmmmm*, I said to myself, *I wonder if that's Kim's plane?*"

When Campbell told of the phone call home, the crowd *ahhh*ed appreciatively. Most were middle-aged and elderly—probably parents themselves, who could grasp the tension and fear that her mother and father must have felt.

After the lecture was over, Robert Mansker of Virginia chatted about what drew him to hear Campbell speak. "I love the A-10," he confided. "I served in armor units on the border of Germany during the cold war in the '60s and '70s. I figured if it got real bad, the A-10 would help out. I was very impressed with the airplane. I worked at McClellan Air Force Base [in California] at one point and repaired A-10s. That gun she spoke of is so heavy, if you took it out, the airplane would fall on its rear.

"I came out of respect for the airplane," he said, his blue eyes shining and a smile on his face, "but you have to admit: 'Killer Chick' has a nice ring to it."

—Mary Collins

MUSEUM CALENDAR

June 7 Exploring Space Lecture Series: The Search for Habitable Planets Around Other Stars. William Borucki of NASA's Ames Research Center ("Bill Borucki's Planet Search," Apr./May 2003) will discuss future space-based missions necessary to find habitable Earth-size planets. Tickets are free and may be obtained at the Lockheed Martin IMAX Theater box office or through Tickets.com (which imposes a nominal charge) at (800) 529-2440 or *www.tickets.com*. Tickets may also be obtained at no charge through the Museum at (202) 633-2398 or *lectures@nasm.si.edu*. Einstein Planetarium, 8 p.m.

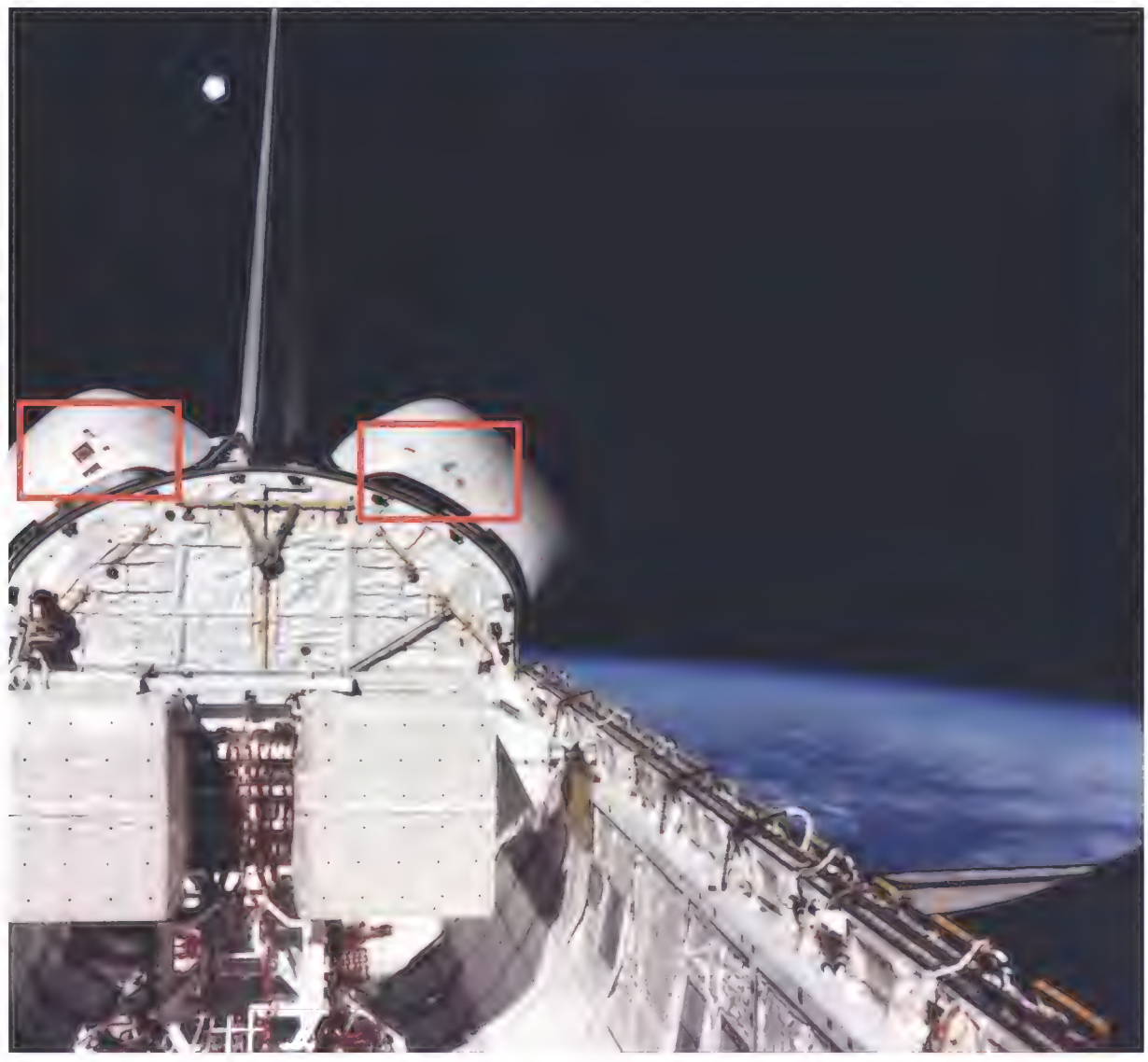
June 10 Lecture: John H. Glenn will share recollections about the early years of manned spaceflight. The former Mercury 7 astronaut will also look back on his return to space in 1998, when, at the age of 77, he became the oldest person ever to experience micro-gravity. Tickets are free and may be obtained at the Lockheed Martin IMAX Theater box office or through Tickets.com (which imposes a nominal charge) at (800) 529-2440 or *www.tickets.com*. Tickets may also be obtained at no charge through the Museum at (202) 633-2398 or *lectures@nasm.si.edu*. Steven F. Udvar-Hazy Center IMAX Theater, 8 p.m.

June 19 Sky Watching. Join Sean O'Brien, staff astronomer of the Albert Einstein Planetarium, and local amateur astronomers for a night of observing dark, star-filled skies through telescopes. Sky Meadows State Park (540-592-3556), near Paris, Virginia, 8 p.m. to 11 p.m.

July 16 Mars Day! Operate a Mars rover and participate in the Red Planet Quiz Show. See a real meteorite from Mars and learn all about Mars from Museum geologists. The program will run at both the National Air and Space Museum on the Mall and at the Steven F. Udvar-Hazy Center at Dulles airport in northern Virginia; 10 a.m. to 3 p.m.

Except where noted, no tickets or reservations are required. To find out more, visit www.nasm.si.edu *or call Smithsonian Information at (202) 357-2700; TTY (202) 357-1729.*

"But That's Why You Fly"



NASA

Columbia's first flight had similarities to its last. In April 1981, controllers were alarmed by the sight of tiles missing from the orbital maneuvering system pods.

On January 16, 2003, the space shuttle *Columbia* thundered into orbit. I attended the launch as a guest of my longtime friend and relative (by marriage), STS-107 pilot Willie McCool.

When Willie had told me he would be flying on *Columbia*, NASA's oldest shuttle, I was thrilled. Two decades earlier, I had a front-row seat for the space shuttle's maiden flight, STS-1, as a trajectory officer at NASA's mission control center in Houston. Few people outside the agency know of the problems we overcame on that first mission, including uncanny parallels to *Columbia*'s final flight.

When I joined NASA's flight dynamics group in 1979, the shuttle was already a year behind schedule, and things looked worse each month. A main engine blew up during a test. Thousands of the orbiter's heat-resistant tiles, designed to withstand a Mach-25 plunge through the atmosphere, fell off during *Columbia*'s first leisurely flight on top of its 747 carrier. Everything from software design to politics seemed to be conspiring to keep us on the ground. But over the next two years we solved all the problems: technical, budgetary, even political. We had confidence in *Columbia*, and on April 12, 1981, we were ready to prove it.

The largest crowd to witness a launch since Apollo 11 packed the coastline at Florida's Kennedy Space Center. In Houston, I sat in my office across from mission control, staring at televisions tuned to the three big networks and listening to a closed-circuit feed of the flight director's communications loop. My shift in the control center would start shortly after launch—assuming everything went as planned.

Which it did, until T minus three minutes, when the ground control officer announced we had lost our critical S-band radar at the Merritt Island Tracking Station at Kennedy. The radar communicates with an onboard transponder to produce more-accurate tracking data. Without it, we could track the shuttle only with less-accurate C-band radars, which simply bounce a signal off the vehicle. I groaned. Flight rules dictated that without S-band capability, the launch must be scrubbed.

Ascent flight director Neil Hutchinson immediately called my boss, flight dynamics officer (FIDO) Jay Greene. "FIDO, Flight. That's a no-go, isn't it?"

"I'll go with two C-bands," Greene replied. Just like that, he overrode flight rules decided upon in tortuous, often contentious meetings. If everything went okay, he would save millions of dollars by avoiding another scrub. If not, as Greene himself liked to say, his ass would be grass.

(A post-launch investigation revealed the cause of the radar loss: The television networks had requested video from some of NASA's cameras, and when those cameras were slaved to the S-band radar, they overloaded the tracking station's computers.)

The count continued. At T minus six seconds the main engines ignited, and at T minus zero the big solid rocket boosters lit.

The next anomaly struck moments after liftoff. Back at mission control, real-time plots showed the shuttle continuing up and up, when it should have been arcing over. I heard Hutchinson ask, "Are we lofting a little bit, FIDO?"

"Lofting, Flight," Greene replied.

"That any problem?"

"No problem."

Sure enough, the shuttle turned and eventually got back onto its trajectory. After his shift, Hutchinson came over to us and pointed to the velocity plot. "I thought it was going to go right off the top of the screen," he said. Which, indeed, it almost did. Incorrect modeling of the solid rocket boosters' exhaust plume and aerodynamic effects caused the orbiter to fly at a higher angle of attack than the wings were designed to take. Years later, STS-1 commander John Young told me, "We had fully deflected needles on the ADI [attitude director indicator]. It was a pretty big mess. But that's why you fly. You learn what you need to do."

The rest of *Columbia*'s ascent was perfect. Half an orbit later, the orbital maneuvering system put the vehicle

into an orbit at an altitude of 150 miles.

Our euphoria lasted less than an hour.

On the second orbit, pilot Bob Crippen opened *Columbia*'s payload bay doors and aimed a camera toward the orbiter's stern. We gasped at the sight: Tiles were missing from the orbital maneuvering system pods. None of those tiles was critical, but what about the areas we couldn't see? If tiles were missing from the belly or the leading edges of the wings, *Columbia* could disintegrate during entry.

The tiles on the leading edge of the vertical stabilizer and the visible areas of the wings appeared to be intact. The tile system in this area had been through a strengthening process two years earlier; the missing tiles had not. Since the rest of the orbiter's critical tiles had also been strengthened, officials assured us they were intact.

Many, including me, suspected the managers were simply crossing their fingers. After all, if critical tiles were damaged or missing there was no way to repair them; the crew was doomed. The same situation would haunt mission managers on *Columbia*'s final flight.

Rumors spread that NASA asked the Department of Defense for help. I later asked entry flight director Don Puddy about it, but he would say only, "Resources were brought to bear." A confidential source eventually told me that both space- and ground-based cameras had imaged the vehicle and shown the tiles were okay. (This was not done on *Columbia*'s final flight. Mission managers cancelled imagery requests because of miscommunication and a lack of hard evidence of tile damage.)

Whether the tiles were intact or not, we on the ground had jobs to do. My main task was generating guidance values, or "block data," to enable the crew to deorbit safely in an emergency on any orbit, even if they were out of contact with mission control. For each orbit, I would select one of the orbiter's six landing sites around the world, taking into account winds, cloud cover, even political considerations. I would then compute the necessary deorbit burn—pointing angles and change in velocity to slow the orbiter for entry—and uplink that information to the crew. I could tell when my data reached the orbiter because I could hear the background chatter of the onboard teletype machine while the crew was talking to mission control.

Columbia performed magnificently. The guidance, navigation, and control systems performed far better than our simulations had predicted, and all the on-orbit maneuvers were flawless. My biggest concern became staying awake. Being caught on national television with your head resting on your console is considered bad form. Young and Crippen did find the cabin getting too cold, and the new Waste Containment System (the toilet) got less-than-stellar reviews. In the post-flight crew debriefing, Young commented, "If we're going to have women fly this thing, they can't be modest, because I don't see how you can use that thing and stay healthy on a reasonably long mission without taking every stitch off and cleaning yourself."

After 36 orbits, and two 14-hour graveyard shifts for me, *Columbia* was ready to come home. A perfect deorbit burn sent the orbiter streaking toward a landing at Edwards Air Force Base in California. The orbiter entered "blackout," in which the ionization caused by tearing through the atmosphere at 24 times the speed of sound prevents radio communications. We would pick it up again, probably about 13 minutes later, when *Columbia* was traveling at Mach 12.3, well before it reached the California coast.

Or so we thought.

As I watched the acquisition-of-signal clock count down, the entry team ground control officer announced that our West Coast tracking network had gone offline. Unknown to us, construction workers at Vandenberg Air Force Base in California had inadvertently cut a power cable, and were frantically trying to splice it back together. This was much worse than losing the Merritt Island Tracking Station on launch: We would have no voice, S-band radar, or C-band radar during the orbiter's most critical flight segment.

The original acquisition-of-signal time passed, and we still had no word from the crew. Had the belly tiles come off? Were Young and Crippen dead?

The extra minutes crawled by. On TV, commentators blathered on, clueless to the drama. Finally, the tracking network came back up, and we finally heard "Hello, Houston! *Columbia* here."

Young assumed manual control, bringing the orbiter through a picture-perfect left-hand turn to runway 23. Fighting the substantial ground effect, a cushion of air generated by the wings as they near the ground, he pushed the vehicle gently onto the runway and brought the nose gear down.

Back at mission control, cheers broke out. I stood at my console grinning while around me legends like Gene Kranz and Chris Kraft waved American flags and smoked cigars.

We knew we had done our jobs well. We also knew we had been lucky. But it wasn't until after reviewing post-flight data, debriefing the crew, and inspecting the vehicle that we discovered just how fortunate we had been.

When the solid rocket boosters ignited at liftoff, the resulting pressure wave reflected off the pad and slammed into the shuttle at loads four times the predicted amount, buckling some of the internal structure that held tanks of propellant. Had those tanks come loose, we probably would have lost the vehicle and crew. Every subsequent launch uses a water suppression system: Seconds before booster ignition, thousands of gallons of water are dumped under the vehicle to dispel the shock wave.

During entry, the crew had another close call while in communications blackout, at just about the exact point *Columbia* disintegrated last year. At the first roll reversal, the nose had drifted four degrees off to the side. Young later told me, "If the trim integrator hadn't trimmed that out, we would have rolled about twice and pulled the wings off. I think that was really a close call." The flight control system had modeled the orbiter's aerodynamics inaccurately. STS-1's flight data was used to correct the algorithms for subsequent missions.

Despite the close calls, *Columbia*'s first flight had gone astonishingly well. The mission had its tense moments and near misses, but we accepted those as part of the risk of a first test flight. We believed once those problems were corrected, the space shuttle would be a safe and reliable flying machine.

A signed photo of Willie hangs on my wall, alongside pictures and awards from *Columbia*'s first flight. When I look at them I mourn not only Willie's death and those of his six crewmates, but also the loss of a great ship that once represented the pinnacle of U.S. technology.

—Terry Burlison

COURTESY TERRY BURLISON

Columbia performed magnificently. Back at mission control, cheers broke out. We knew we had done our jobs well. We also knew that we had been lucky. But it wasn't until after reviewing post-flight data, debriefing the crew, and inspecting the vehicle that we discovered just how fortunate we had been.

Shop Talk

WAYNE SHIPP

In the late 1940s, I got a job at the Douglas Aircraft plant in El Segundo, California, where AD-1 Skyraider dive bombers were being crafted in great abundance. My first priority was to learn the jargon that covered everything from tools to storage areas.

Mechanics usually had their own hand tools, but the factory stocked the more unusual stuff in the tool room, where items could be checked out. Some of the tool names were descriptive enough: A very fine, flat file for hard metal, for instance, is still called a mill file. Another, intended for soft metal, is a vixen file. Still another is a bastard file. A lead hammer is just a lead hammer, though it was sometimes called a persuader.

To measure the pull required to actuate certain devices, you checked out a fish scale. Not a nickname—it was the same kind of scale that fishmongers used to weigh their wares.

When an aircraft's hydraulic system had to be pressurized to power various systems without firing up the engine, you called for a hydraulic mule. Powered by an electric or gas motor, it furnished hydraulic pressure to retract or extend the landing gear, flaps, or what have you.

When you needed to rivet together parts in an area with no room for a conventional rivet gun and bucking bar, you checked out a rivet squeeze gun. This device operated on air pressure and had a pair of jaws, one of which was stationary. If the jaw moved in an arc, like the jaws of pliers, you were using an alligator squeeze. If the jaw moved linearly and the stationary jaw and moveable jaw looked, in profile, like the letter C, the tool was a C-squeeze. If you had a very small space to work in and only light force requirements, you checked out the diminutive baby alligator squeeze or a baby C-squeeze.

A typical visit to the tool room might go like this: "Gimme a 2X gun, a scoop of dum-dum, a handful of those icebox rivets, a can of MEK, and 25 feet of one-inch spaghetti." A 2X rivet gun had twice the hammering power of a 1X gun. Dum-dum was a sealant called EC-801 Compound, MEK was an acronym for the solvent methyl ethyl ketone, and icebox rivets would lose their unique properties unless they were kept chilled. Spaghetti was Irvalite plastic tubing, through which electrical wiring was routed.

"A tray of number 10 Clecos, a tray of 21s, a hot dimpler set for five thirty-seconds, a Christmas tree, a bottle of zinc chromate, and some chrome pickle."

"I wanna check out the hookah and the ouija board."

"Twenty-five three-sixteenths Hucks and collars."

The mechanics' favored area of the tool room was Mom's Kitchen, which was run by a pleasant older lady. When you wanted spark plugs, you went to Mom's Kitchen to draw a couple of racks. Two racks each held enough spark plugs for one Wright R-3350 twin-row radial engine.

The area got its nickname when employees discovered that because the cabinets were equipped with heating elements to keep spark plugs dry, they were dandy for heating lunch. Chili, baked beans, soup, and hot dogs sure beat cold, stale sandwiches.

This practice was against company rules, of course, as it took up room intended for the spark plugs. And true, the plugs were left out in the open, exposed to humidity while the ovens were chock full of food. But the place smelled heavenly, just like a real kitchen. After lunch, the plugs were dutifully replaced in the ovens and restored to their dry state. However, the occasional explosion of a can of overheated ravioli made such a mess that management used to conduct surprise inspections to see just what was inside the cabinets: Champion spark plugs or Campbell's chicken noodle.

The occasional explosion of a can of overheated ravioli made such a mess that management used to conduct surprise inspections of the tool room to see just what was inside the heated cabinets: Champion spark plugs or Campbell's chicken noodle.

Mom would often singe her fingers attempting to get the food out and hidden and the spark plugs back in before management arrived in an unannounced sweep. She was usually successful, having gotten advance notice through a first-rate signal system run by the mechanics. Mom also had seniority, more than most of the management team. Even when they found food in the ovens, nothing much happened.

So it was, with the help of vixens, bastards, mules, alligators, baby C-squeezes, and fish scales, we managed to build airplanes, nurtured by piping-hot contraband lunches fresh from the big spark plug ovens.

—O.H. Billmann

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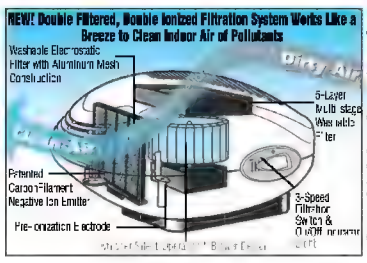

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The People and Planes of SPRUCE CREEK

The wake-up call in this Florida neighborhood: Rise, shine, and fly. ★ by Debbie Gary ★ Photographs by Cameron Davidson

"Smoke on," the groom radios his four wingmen. Five lace-white trails unfurl behind the five SIAI-Marchettis. Below, 400 guests watch the airplanes arc through a stained-glass-blue sky. It is a perfect day for a wedding.

Inside the lead airplane, pilot Bob Gandt and his passenger, Anne Busse, are about to recite their vows. Just past the crowd, the five aircraft bank gracefully and climb for a turnaround, while Reverend John McCollister asks if anyone has reason why Gandt and Busse should not marry. Of course no one does, but at that moment Gene McNeely zooms past at treetop level in his North American AT-6, belching smoke and rocking his wings, playacting an irate lover. After a few laughs McCollister says, "Well, he's not transmitting, so the heck with him."

When the bride, groom, and wingmen return for the I Do Pass, McCollister pronounces Gandt and Busse man and wife. The grand finale is the Missing Groom Flyby, with Gandt's airplane pulling up and away from the others.

The Gandts, McNeely, and most of the wedding guests are all residents of Spruce Creek Fly-In, an airpark just outside of Daytona Beach, Florida. At Spruce Creek, which has a 4,000-foot runway and 13 miles of taxiways, residents live with their airplanes, and flying is nearly as common and certainly as simple as backing out of a two-

An upscale residential development, Spruce Creek is also a pilot playground, where Tim Plunkett (opposite) fulfills a youthful fantasy of being the Red Baron.

THIRD IN A SERIES

MAP: JUAN THOMASSIE

During Saturday morning Gaggle Flights (bottom), resident pilots fly to nearby airport restaurants for breakfast.

car garage. Pilots like Gandt and McNeely live here because they love the convenience of the one-minute commute from their back door to the runway. They also love having neighbors who build airplanes, fly out for breakfast, lunch, and dinner, sightsee from the air, and practice formation flying. Living in the airpark is a lot like being at an airshow that begins anew each day.

In the morning, while you sip coffee by the pool and listen to the scrub jays and the catbirds in the palmetto trees, you might hear an engine fire up down the street. You guess by the sound of it that it's the big radial in Keith Phillips' Pitts 12. Then you hear Bob Wahl taxi by in his Great Lakes or John Champlain in his Piper Comanche. If it's Saturday morning, one or the other will be taxiing to The Tree for the Gaggle Flight, a weekly formation flyout to breakfast that begins at a large oak in Spruce Creek's aptly named Windsock Park. If you aren't flying with them, you hop in your golf cart to follow and watch them take off in groups of two, three, and four airplanes from the 176-foot-wide runway. (Nearly everyone in the neighborhood has a golf cart, since cars are not allowed on most taxiways.)

If it's Wednesday midday, you might see Ron Vickrey and a group of Beech Bonanza pilots meet at The Tree for their weekly luncheon flyout. Florida is a flying-friendly state, with its sunshiny days, level terrain, and abundance of airport restaurants like the

Fly By Café in St. Augustine, the Wings Bar and Grill at Bunnell, and the Outer Marker Café in Titusville. Florida also has a lot of long, wide runways, former World War II military airstrips that are perfect for group landings.

In fact, Spruce Creek began life as a Navy airstrip. It is now the largest private airpark in the United States, a 1,140-acre gated community, seven miles south of Daytona International Airport, with about 4,500 residents and close to 650 aircraft. There are some 1,600 buildings, including residences, hangars, and commercial space.

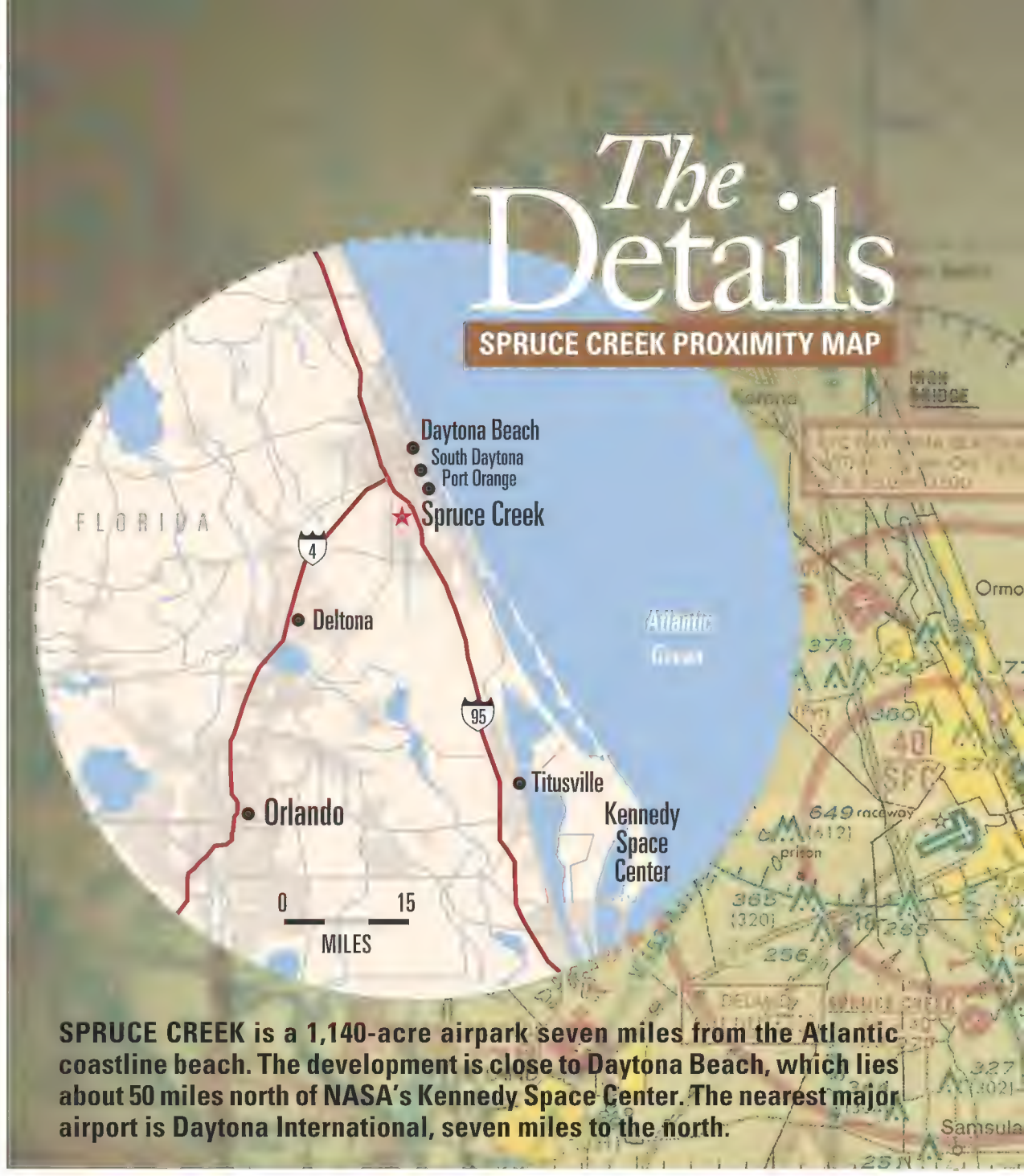
During World War II, Spruce Creek was the site of the Samsula Auxiliary Airfield, an outpost for Daytona and Deland Naval Air Stations. After the war, the federal government gave the land and runways to the city of Daytona Beach. Since the city already had a big airport close to town, the strip and acreage lay empty, except for drag racers, fishermen, hunters, and nature lovers. The parcel of land is seven miles from the Atlantic Ocean, and with short mild winters, long hot summers, afternoon showers, and moist ocean breezes, it soon returned to jungle. Even now, the northern half of Spruce Creek nestles against the dense woods of a 2,000-acre nature preserve. The creek for which the place is named, a rich, tea-colored stream, is home to herons, egrets, alligators, fish, and manatees.

The Fly-In's developer, McKinley Conway, found the site as he flew around the country during the 1960s, looking for the perfect place to design his dream airport city. Conway, who in 1940 had two engineering degrees and a pilot's license by the age of 20, had written dozens of articles promoting industrial airparks and the live-in, fly-in concept. He convinced Daytona Beach officials that Spruce Creek was the perfect place for airplane lovers, but city officials didn't want to develop it themselves. So from 1969 to 1979, Conway and a group of Atlanta businessmen laid the groundwork for transforming the patch of wild Florida into a place where people could live.

But Conway's group ran into financial setbacks, and in 1979, real estate developer Jay Thompson took over the project. Thompson was already developing the upscale Bent Tree Golf and Racquet Club in Sarasota, Florida. For Spruce Creek, Thompson downsized Conway's plans, reducing the number of subdivided lots from 6,000 to 2,400 and commercial space from three million to 300,000 square feet. Some of that space now includes a restaurant, maintenance shops, fuel pumps, five real estate offices, hangars, and public parking.

Construction at Spruce Creek inched along. In 1983, when Delta pilot Tim Plunkett first looked at the place, there were so few houses his wife refused to move there from Miami. By 1988, when he looked again, there were 100 homes, including one owned by John Travolta. Most residents' eyes glaze over when they are asked about Travolta (he is the first subject many non-residents inquire about). Plunkett recalls seeing the actor stroll by his house. "He's a nice guy who's crazy about airplanes," says Plunkett. "He had a G-II, a Learjet, and a Canadair Tutor. He's an airplane lunatic, but it has to be a jet. When he bought a Boeing 707, he couldn't get it in and out of here, so he moved to Ocala," where the actor lives in an upscale airpark that has a 7,550-foot runway.

Plunkett is an airplane lunatic himself. "It is not a hobby," he says. "It's not even a job. It's a life. It's who you are." He owns a twin-engine Beech Baron, a MiG-15 fighter, and



Vital Stats

SPRUCE CREEK AIRPORT

Dining: Try Pepino's, in Spruce Creek's commercial district.

Don't Miss: Spruce Creek's annual Wings and Wheels Day, held every March, when residents display the vintage automobiles, motorcycles, and aircraft normally hidden in their hangars.

Living There: For information about community amenities and listings of available properties, visit Spruce Creek Fly-In Realty at *www.fly-in.com* and the Spruce Creek Property Owners' Association at *www.scpoa.com*.

Tim Plunkett (second from right) loves airplanes of all eras. That's a MiG-15 in his hangar, and he also owns a World War I Fokker triplane replica (below), which draws the attention of even Spruce Creek's non-pilots.

an airworthy replica of a World War I Fokker triplane. His heart belongs to the Fokker, which he flies every chance he gets.

When Plunkett was a college student, his red bicycle earned him the nickname Red Baron, but he didn't understand the name's significance until he saw *The Blue Max*, a 1966 film about World War I pilots, including German ace Manfred von Richthofen, known as the Red Baron. Somewhere between watching the Fokker triplane's performance in the screen version of the Battle of the Somme and the end of the movie, Plunkett decided he had to fly, and it had to be in that airplane.

A year and a half ago he found a Fokker triplane in North Carolina and brought it back to his hangar in Spruce Creek. "There are a lot of non-aviation people at Spruce Creek," Plunkett says. "But when I take this airplane to The Tree, even those people come out and know its name and who the Red Baron was. When I take it up and make a couple passes down the runway, I see about 50 golf carts headed for The Tree."

About half the residents of Spruce Creek are the "non-aviation people" that Plunkett mentions, and most of these non-flying families don't live on the taxiway lots, which have risen steadily in value and are among the priciest in Spruce Creek.

When they first moved here, Ron and Sylvia Vickrey were skeptical about the development's investment value, but they're now convinced they made a wise choice. Before moving to Spruce Creek in 1992, the Vickreys lived in an airpark of about 100 homes near Chicago. Although that development is not a gated community and all its streets are open to non-residents, their home sold quickly in the slow real estate market of the early 1990s. Still, the Vickreys worried that an airport home was an investment in a niche market, and when they retired to Florida, they wanted a surer thing. At first they looked at everything but airpark properties. Then they realized they were used to having their airplane in the

back yard. "Not living here would be like keeping your car three miles away and having to take a cab to drive it," Ron says. "So here we are. As it turns out, I wish now I had bought the 10 lots around me that were empty, because they are selling for three times what I could have bought them for 10 years ago."

Aerial newlywed Bob Gandt, an author and retired Pan Am and Delta captain, also lived in another airpark, Eagle's Nest, 40 miles northwest of Spruce Creek, near Crescent City. "It was very bucolic," he says, "a little oasis in the middle of rural Florida, very upscale, very rural. We had a bit of acreage around us and we had critters—a flock of Sandhill cranes and an alligator in the lake behind my house. It was a small community with only 14 houses, like a little colony, whereas this is virtually a town." And like a town, it has neighborhood diversity.

In one section of Spruce Creek, aircraft are parked in planeports, open-air structures with a roof and three walls but no door. In another, airplanes are parked beside houses, like cars in a driveway, and another area features paired houses, with duplex-style hangars behind them. In Keith Phillips' neighborhood there are multiple large hangars accessible from Cessna Boulevard, one of the airpark's major thoroughfares, which runs behind Phillips' house. Much of the taxiway network feeds airplanes from homes, down Cessna Boulevard, and to the airpark runway. Auto traffic to Spruce Creek's commercial district also travels down Cessna Boulevard. Aircraft taxi down the middle, while cars drive on either side.

Phillips has two hangars, which house numerous aircraft he has built over the years. One is a sleek red Swearingen SX-300, which looks like it's going 250 knots standing still. Another is a bright yellow Pitts 12 biplane with a 400-horsepower radial engine. It's the SX-300's polar opposite: It has a fat fuselage, wing struts and flying wires, and its propeller blades are as big as the leaves on a banana plant.

The hundred pilots who are official members of the Gaggle Flight meet at

"Here I build airplanes, work with the airplanes, jump in the airplane and go flying any time, night and day," says Bob Wahl (top) of his life at Spruce Creek.

Like many gated communities, Spruce Creek has a golf course, along with tennis courts, swimming pools, and a country club.

Five Spruce Creek pilots, all of them owners of SIAI-Marchetti SF.260s, founded the Marchetti Mavericks, a non-aerobatic formation team that performs at airshows.

Phillips' hangars periodically to socialize and review the group's procedures. They try to avoid taking themselves too seriously, Phillips says, but formation flying is dangerous unless everyone follows the same plan, so they have rules and safety meetings.

With all the flying that goes on at Spruce Creek, the airport has a remarkably good safety record, especially considering that it has no control tower to direct traffic. Instead, pilots announce their positions and intentions over a common VHF radio frequency. Like any airport, though, Spruce Creek has had its share of accidents: On April 10, a Pilatus P3-05 hit a tree near Spruce Creek while returning from a Gaggle Flight breakfast in Titusville. Both pilot and passenger were killed. Four days later, a visiting pilot and two passengers were injured when their King Air crashed during an aborted landing in Spruce Creek.

One Thursday afternoon, a group of pilots hang around Phillips' office chatting and telling jokes while he writes the script for their Saturday morning flight past a beach parade. Someone gives the update on a youngster they've sponsored to take flight training, then Phillips tells a story about an impromptu race he was in against record-setting, time-to-climb pilot Bruce Bohannon at last December's centennial of flight celebration at Kitty Hawk, North Carolina. "The Pitts is full of gas so it's extra-heavy, and the wheel pants are off, so there's extra drag," Phillips says. "Still, I beat him into the air. Then we match each other in the climb, so I pull a little steeper. Bohannon [flying a heavily modifed RV-4] matches it. At 1,000 feet, he's a teeny bit ahead. My propeller was even with his engine. Later, Bohannon [who reached close to 45,000 feet] said, 'You know, Keith, if you had had a light load of gas, you would have beaten me.' "

Saturday, on the way to breakfast in St. Augustine, the group of 26 airplanes will zip along the coast at Ormond Beach for a flight past the Centennial of Speed Parade. Bob Terry and Charlie Tinsted will be on the beach reading Phillips' script describing the group's airplanes and the history of the Gaggle Flight, while Phillips leads the way in his SX-300.

At Spruce Creek, there is something to do every day, and somebody to do it with. Gaggle pilot Bob Wahl and his wife Lorraine first tried retirement in the Florida Keys. "In the Keys, you fish and play tennis and drive 30 or 40 miles to Marathon to fly your airplane," he says. "It's a beautiful area, but there really wasn't enough to do. After a while, if you were going to live there you would probably start drinking." Twelve years ago, they moved to Spruce Creek. Wahl built model airplanes as a kid and now has built four full-size airplanes, including a Stewart F-51, a Pitts 12, and his current project, an F-1 rocket.

Not every hangar in the park is stuffed with airplanes. Brenda and Bill Lear Jr. (the son of Learjet creator William P. Lear) bought a home with a hangar, but they both sold their airplanes before they moved in. Without an airplane, their hangar is a workshop and a warehouse for, among other things, copies of Bill Lear's autobiography, *Fly Fast... Sin Boldly*. For medical reasons he doesn't fly anymore, but he takes a radio and his golf cart to The Tree on beautiful afternoons and teases other pilots with his landing critiques. ("That's a nine and a half, Gene," he says. "Your tail was too low.")

On weekday afternoons at 4 p.m., Lear and a group of guys, many of them retired airline pilots, head for Darrel Bassuener's hangar, near the runway. They arrive by car, airplane, golf cart, bike, and motorcycle, and they sip soda and beer alongside Bassuener's North American T-28 (the sumo wrestler of single-engine airplanes). They tell stories and try out jokes. On one side of a long fold-up table, John McCollister repeats the local favorite, "Did you know that when you die at Spruce Creek, going to heaven is a lateral move?" On the other side of the table, someone tells the one about the novice copilot breaking out of the clouds and spotting the really short runway that is 150 feet long and 10,000 feet wide.

Airplanes may be their preferred way to travel, but residents still enjoy other sporty forms of transportation.

What do Spruce Creekers do when they're not flying? Talk about flying.

Outside, the airshow goes on. In the background, Dennis Demers' Cessna Citation jet spools up and heads for Vermont. Two RV-8s fly in a tight formation, a Republic Seabee turns on downwind, and Orval Fairbairn taxies by in his 1946 Johnson Rocket.

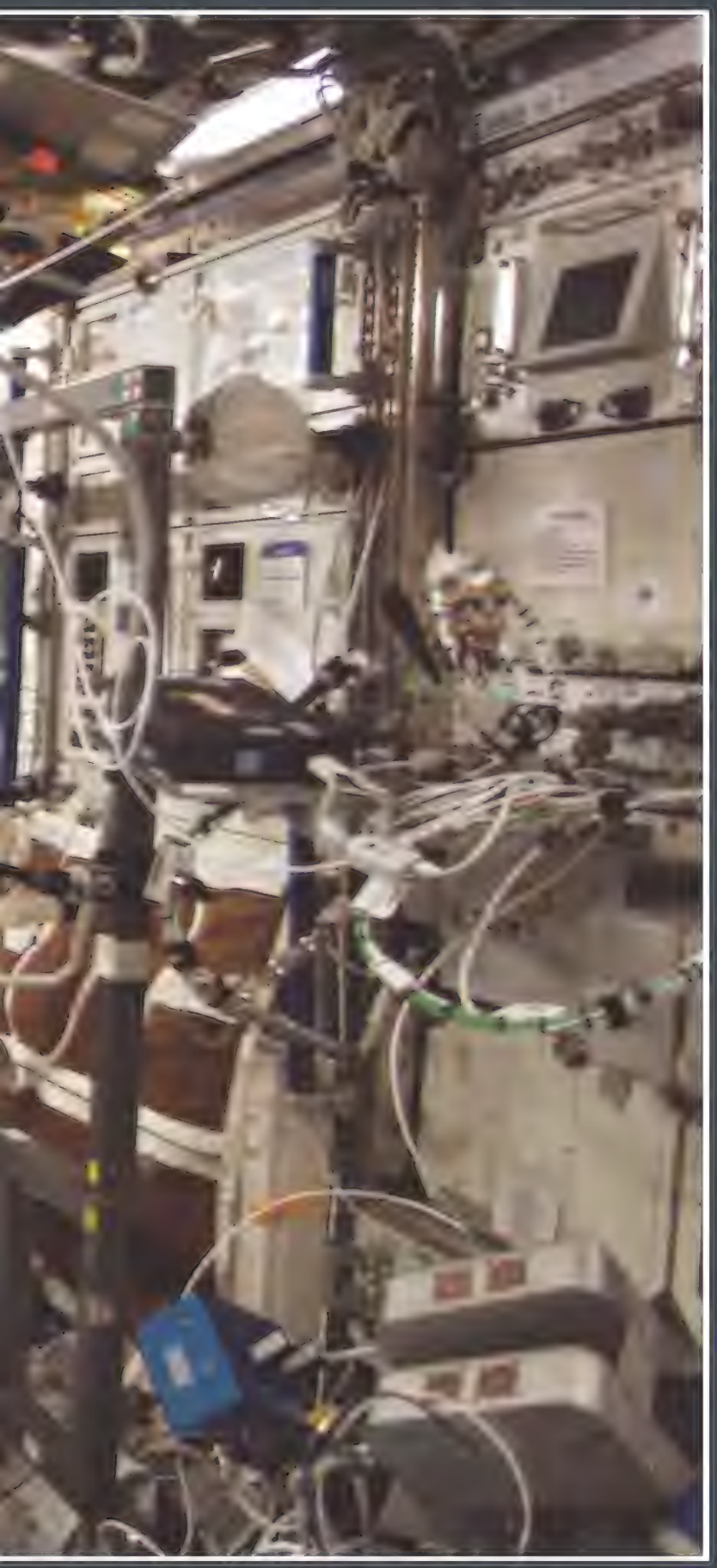
Ed Lu on keyboards, inside the station's U.S. lab last year. Opposite: At the other end of the station are two Russian modules, which loom in Discovery's *view as it backs away after a visit in August 2001.*

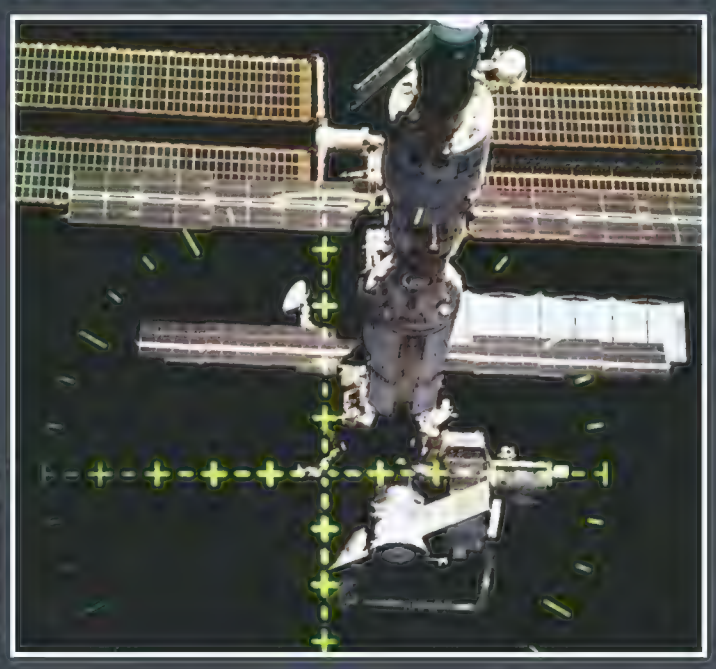
LAST JULY, just outside the cosmonaut training center in suburban Moscow, I enjoyed dinner and a few beers with a group of Japanese and American astronauts, most of them bound for the International Space Station. Walking back to our duplex just after sunset, a few of us kept an eye out for two colleagues who would soon pass 220 miles overhead. Gazing above the darkening birch forest, we first spotted the constellation Cygnus. A moment later, the familiar stars of the Northern Cross were joined by the bright beacon of the space station, tracking east across the sky. Ed Lu and Yuri Malenchenko, the seventh crew to live aboard the outpost, were likely ending another long workday. They, along with my dinner companions and the thousands of people who have built the space station, believe it will be the key to sending human explorers into deep space.

Will it? Midway through its sixth year in orbit, the space station remains in a frustrating holding pattern. While its construction has gone more smoothly than NASA and Russian engineers had dared to hope, the project's constant political and budgetary woes have made its eventual success seem doubtful.

BY THOMAS D. JONES

For the astronaut residents, though, it has been a different story—of learning to live in space rather than just visit there, while coping with a sometimes testy partnership between two very different cultures. No one





ALL PHOTOGRAPHS NASA

THE FIRST 1,000 DAYS

A former shuttle astronaut takes a good, hard look inside the International Space Station.

said it would be easy, and it hasn't been. Yet the station has chalked up modest successes, most of them unknown to the public.

Since the first three-man crew moved in, on November 2, 2000, 22 people, all Americans and Russians, have completed tours ranging from 117 to 181 days. The current residents, referred to as Expedition Nine, are Mike Fincke and Gennady Padalka; until the space shuttles resume flying, the station will be staffed by just two people at a time.

Even with three on board, the astronauts don't lack for elbow room. The four pressurized modules (the Zvezda living quarters, Zarya stowage module, Unity docking node, and Destiny laboratory) plus a couple of closet-size airlocks offer a total of about 15,000 cubic feet of living space, equivalent to a three-bedroom house. Compared to the cramped shuttle, the station has an expansive feel, with work and living areas stretching half a football field from Zvezda to the aft end of Destiny. Says Don Pettit of Expedition Six, "You can go all day long and not even see anyone."

Visiting the station during a shuttle construction flight in February 2001, I was surprised by how large and how comfortable it was. When my crew snaked through the airlock tunnel from *Atlantis*, my first impression was of hovering in the bright and airy foyer of a new home. The Zvezda module held two sleeping compartments where commander Bill Shepherd and Sergei Krikalev bunked just across from each other. At the time, Yuri Gidzenko was forced to sleep strapped to the wall forward in the Zarya cargo module, but since then Destiny has been outfitted with a cozy, prefab sleeping compartment, popular with its tenants. Shepherd and Krikalev had personalized their cubicles with family snapshots and other mementos, and someone had affixed an icon of the Madonna and Child above the portal to the Soyuz lifeboat.

Sharing tight quarters for weeks on end, crew members have learned to preserve one of the scarcest commodities aboard a spacecraft: privacy. The Zarya module, for example, with its long central passageway, made a good "shower room" on Expedition Two, but in space, you can't simply shut the door. A closed hatch on Zarya could have impeded passage to a Soyuz escape vehicle on the other side. Susan Helms, who spent nearly six months as Expedition Two's lone female, says her crew worked out a solution: A Zarya hatch swung partially closed meant "Knock before entering," enabling her to bathe or wash her hair on Friday nights free of intrusions.

The station crews' mealtime customs have also evolved. On Expedition Four, Dan Bursch recalls that Commander Yuri Onufrienko set the tone for the two more casual Americans: "Yuri kind of expected us to be there," he says. What time did they all float in to dinner? "Usually it was when Yuri wanted to eat." The Russians generally take the social aspects of dining more seriously than Americans, who on busy shuttle flights grab food on the run and eat separately. The Russian style has prevailed on the station. Zvezda was launched in 2000 without its wardroom table, but the first crew decided not to wait for its arrival on a Russian Progress supply craft. Using sheet metal from an empty cargo box, Krikalev and crew designed and built the table from scratch. Soon he and his companions were breaking bread Russian-style. For Susan Helms, Friday night conversations around the dinner table with crewmates Jim Voss and Yuri Usachev were one of the highlights of her stay on the station. She likens them to sitting around a captain's table on an earlier century's sailing ship. Helms recalls Voss, after a meal near the end of their stay, lamenting: "I don't want this part of it to end."

Spanish astronaut Pedro Duque, playing with a water droplet last October, arrived and departed on a Soyuz.

A station astronaut's life unfolds in long weeks of routine maintenance and science work. Every day after rising (morning in Moscow, roughly midnight in Houston), the as-

tronauts clean up, share a quick breakfast, and spend 10 hours on the job in free fall. Crews take a break for lunch and devote at least 90 minutes daily to exercise. After dinner, they mix housekeeping chores with relaxation: e-mail, calls to home, and perhaps some music, reading, or photography. Saturday and Sunday are half workdays, with sometimes a special meal or movie together.

The routine is—or was, until last year's *Columbia* accident—interrupted at irregular intervals by shuttles and Progress craft arriving with new station hardware and supplies, as well as planned spacewalks and unscheduled repairs.

The pace of work has varied. The Expedition One crew members had their hands full from the start, since they had to open the station and set up many of its systems. Compared to his 15 months on the Russian station Mir, says Krikalev, "the workload was pretty high, but it was expected. We knew…we were going to be busier than on average missions." I saw this during my week-long visit in 2001. After a long day of spacewalking or outfitting the lab's interior, I would drift off, exhausted, to my sleeping bag on *Atlantis*. But as I floated down through the docking tunnel, I could see Shep, Sergei, and Yuri still at work. The three were lucky to get five or six hours of sleep a night. Add in the chore of unpacking and packing the shuttle and the strain of receiving guests, and our hosts must have felt a sense of relief as they watched us pull away in *Atlantis*. Expedition Four's Dan Bursch echoes a sentiment many station astronauts feel about visitors: "We were glad to see them arrive, and happier to see them leave."

Though the second expedition crew, which arrived in March 2001, didn't have as many setup chores, they immediately faced an annoying problem: The alarm software for the newly attached lab, which monitors the station's critical systems, was trigger-happy. Before launch, its fault detection limits had been set too narrowly. The result was a random stream of caution and warning alarms—"false 99.9 percent of the time," Voss recalls. On the first night, a fire klaxon jarred the astronauts out of their bunks, and repetitive alarms proved so annoying that for a time, one person had to sleep by the computer to quickly silence the noise. The crew soon grew skeptical of all alarms, which by the end of the mission totaled more than 900.

There also have been malfunctions with potentially serious consequences. During Expedition Four, the station temporarily spun out of control. Commander Yuri Onufrienko and flight engineers Carl Walz and Dan Bursch were aboard on February 4, 2002, when one of the Zvezda module's computers failed, which stopped the flow of pointing information from Russian attitude sensors. Blinded, the U.S. guidance computers lost their ability to command attitude, and the station began to drift slowly out of orbital alignment. That meant that the solar arrays, no longer facing the sun, would stop producing power. Walz remembers the matter-of-fact call from astronaut Mario Runco in mission control: "You guys are going to lose attitude control. We'd like you to work the power-down steps."

Wow, here we go, thought Walz as he and his crewmates waded into the emergency procedures. They began cutting off electricity to experiments and non-essential systems, and shutting down ventilation fans and all but one light in each module. Communication was lost as the S-band an-

Yuri Usachev (left) stays groomed during Expedition Two; Peggy Whitson (below) faces the press in 2002.

Susan Helms likens dinner conversations to sitting around a captain's table on an earlier century's sailing ship.

tenna lost track of its relay satellite. "We were sitting in this darkened tube, waiting for instructions," Walz recalls. The three got out their flashlights and worked the procedures while waiting for a pass over a Russian ground communications site. Walz remembers thinking, *How are we going to get out of this*? He floated around the darkened station toting his flashlight and, of all things, a wrench. "I felt like I needed to carry a tool, something to make me feel I was doing something useful," he says.

By now, the station had rolled about 150 degrees off its normal attitude, and the giant solar arrays were no longer catching sunlight. But Walz drew confidence from his Russian commander. "Yuri had been through this drill before on Mir," he says. Eventually, he and Bursch worked out with Houston a way to get the solar arrays pointing properly. "Dan called out the sun's position by looking out the lab window," Walz says, "and I was able to use a laptop to swivel the arrays into sunshine." Once the station batteries were recharged, ground controllers restarted the Zvezda computers and regained attitude control. The episode had lasted seven hours.

Such systems failures, though infrequent, would be impossible to overcome without the control centers looking over their shoulders, say the station astronauts. During the Zvezda failure, recalls Walz, "[mission control] essentially ran the vehicle, and we were their hands." On such occasions, Susan Helms' crew jokingly referred to themselves as "meat servos." But it was more common, Helms says, and far more satisfying, for the crewmates to come up with their own solutions in the course of day-to-day work.

The first crews, particularly Expedition One, were in radio contact with mission control only 10 to 20 percent of the time, mostly via Russian ground stations. That had some advantages, according to Krikalev. Being able to talk to the ground any time he wanted was good, he says, but "having the ground able to talk to you anytime they want to is not very desirable." Space station work can require intense concentration; controllers have since learned not to interrupt crews for a routine shift change of console operators.

As more communication pathways have come online, contact with the ground is now available as much as 90 percent of the time. Peggy Whitson of Expedition Five "ended up just chatting anytime I felt like it, anytime I needed to. In the end I think I ended up being closer to my ground team because I involved them more." With near-seamless coverage, even nonverbal communication became possible. Whitson remembers a day when she and Valery Korzun, immersed in repairing a balky air scrubber in the lab, had wormed their way so deeply behind an equipment rack that their microphone was out of reach. Houston, watching via satellite TV, could see only Whitson's feet sticking out from behind the refrigerator-size rack. Capcom (capsule communicator) Charlie Hobaugh, reading off repair instructions, radioed, "Peggy, I realize you're busy right now. If you copy, just wiggle your right toe." Whitson heard and obeyed. Hobaugh hit the mike button again, and "I could hear the whole [control room] laughing," she recalls.

The crew soon grew skeptical of all alarms, which totaled more than 900 by the end of the mission.

The cross-cultural aspect of the International Space Station has perhaps been the most difficult, often requiring diplomacy and patience. At first, when most of the hardware was Russian, Moscow was the lead control center. Houston was supposed to assume that role with the February 2001 launch of the Destiny lab, but "the shift never officially took place," says Jim Voss. "It just gradually evolved over many months." Station flight director Andy Algate thinks NASA bowed to Russian sensitivity over losing the most visible symbol of their once preeminent role in station operations. It wasn't until months later, he says, that NASA's station program manager, Tommy Holloway, finally wrote a letter to Moscow stating that the handover had occurred. Even today, NASA goes out

Mike Foale (above, far right, during a Moscow press conference) was the lone American on the eighth station crew, just as Bill Shepherd (opposite, center, with Sergei Krikalev, left, and Yuri Gidzenko) was on the first.

of its way to avoid using the term "lead control center."

Nothing has strained the U.S.-Russian partnership like the very public dispute over sending tourists to the space station. In early 2001 the Russian space agency announced that American millionaire Dennis Tito would visit the station on a Soyuz taxi flight. NASA Administrator Dan Goldin, citing safety and operational concerns, made it clear that Tito was not welcome aboard the station. That led to an embarrassing incident in which Tito and his Soyuz crewmates were denied entry to the training facilities in Houston. Reporters began asking Helms, Voss, and Usachev questions about the controversy while the three were on board the station. Voss recalls his disgust with the whole spectacle. "They asked us if we were not going to open the hatch when [the Russians] got tourists up against NASA's wishes. What do you say in a case like that? Of course we were going to open the hatch," he says.

Goldin ultimately relented, but once Tito came on board, things were just as awkward. Moscow scheduled a joint press conference, but NASA ordered Helms and Voss not to participate. "That made it very difficult," recalls Voss, "because we had to tell [Usachev] that we could not do it." The American astronauts also were forced to ask Tito to stay out of the U.S. modules. "Putting us in a spot like that was upsetting to all of us," says Voss. "But we weren't upset with each other. I was angry with NASA."

Because of his limited ability to speak Russian, Tito had been unable to converse much with his cosmonaut crewmates during his once-in-a-lifetime trip to orbit. "He had just gone through this amazing launch experience two days earlier," recalls Helms, "and he couldn't tell anyone about it. He was gushing when he showed up, and it was really fun to see him so excited."

Carl Walz, who was on board when South African millionaire Mark Shuttleworth came calling in April 2002, says the station makes a poor hotel for tourists. "When you have extra people in general, there's less room, and your life support system has to work harder," he says. Since everyone has to exercise daily, "you can build up locally heavy [carbon dioxide] concentrations.... If you were the third guy [to exercise], they [the visiting crew] had probably used up all the [oxygen]!" Helms adds, "I think that space tourism is a fantastic idea.... [But] there should be the equivalent of tourist destinations, much like you have diving tourist destinations now."

Tensions over Tito's visit merely highlight what every space station astronaut knows from daily experience: In essence, the station is run as two distinct enclaves, with Houston and Moscow ruling over their respective spheres of influence. NASA originally envisioned that the crew members—speaking English as the agreed official language—would be equally expert on all station systems, no matter which partner had built them. Actual practice has fallen short of that ideal. Everyone speaks Russian to Moscow and English to Houston, and Moscow typically assigns work on the Russian segments—Zvezda and Zarya—to cosmonauts, while NASA astronauts look after the U.S. modules.

Astronauts and flight directors have come to agree that this makes operational sense, although the realities of spaceflight often muddy the division of labor. After a spacewalk in February 2002, Carl Walz and Dan Bursch fired up a regenerator in the station's airlock to renew a pair of air scrubber cartridges. As a small oven heated the spacesuit canisters to strip them of carbon dioxide, a strong odor flooded the airlock and Unity node. Walz and Bursch hurriedly shut down the unit and sealed the airlock off from the rest of the station. All three crew members reported slight headaches, and for the next two days they holed up in Zvezda while flight controllers filtered the U.S. segment's air supply. Engineers traced the problem to unsealed inlet caps on the old scrubbers, which had absorbed enough moisture to produce a bumper crop of mildew. The bake-out then produced what Walz called a world-class whiff of "moldy locker room." Operations were restricted for only 48 hours, but the aftereffects of the incident lingered far longer, reminding both centers of how inextricably the two segments were linked.

Still, after nearly four years of joint operations, important differences remain unresolved. Russian and American space doctors are still negotiating, for example, the best method to synchronize the sleep cycles of station crews with those of visiting crews so that all can work effectively together. While the flight surgeons debate which circadian shift protocol to follow—all at once (Russian) or gradually (American)—the station crews have had to endure some fairly disruptive sleep schedules.

The Expedition Two crew, already tired from long hours packing up a just-departed Progress in April 2001, were scheduled to move their Soyuz lifeboat to another docking

port to prepare for space shuttle *Endeavour*'s arrival. Moscow's flight plan called for the station crew to turn in at noon, wake up in the early evening, then work clear through the following day. But "it's virtually impossible to go to sleep at noon," says Voss. "We tried to, but you just can't. So we wound up staying up all day and then all night."

After a drawn-out series of hatch closings and pressure checks in preparation for the Soyuz undocking, Voss says, his crewmates were exhausted. "We were in the FGB [Zarya], waiting for the final 'Go' to close that last hatch to go into the Soyuz, just the three of us, sitting there talking," he recalls. "And the next thing I knew, I woke up, and all three of us had fallen asleep." The Soyuz switch went ahead without any problems, but in their debriefing the crewmates highlighted the incident as "the most unsafe thing" they did on the station. What's more, says Voss, who until recently was a senior operations manager for the station in Houston, "They still do bad sleep shifts.... They've not fixed that problem."

In nearly four years of orbiting Earth, station crews have had a unique perspective on the new century's horrors—terrorist attacks and wars, as well as the February 2003 destruction of space shuttle *Columbia* and its crew. The *Columbia* accident, which happened midway through the Expedition Six crew's tour, was a wrenching experience for the three men living on the station—Ken Bowersox, Don Pettit, and Nikolai Budarin. Yet life resumed in space, just as it did in Houston. After watching uplinked video of the memorial service, the astronauts rang the ship's bell seven times in honor of their friends. "We spent 15 or 20 minutes in silence, and then we moved on," Bowersox recounted later during an in-orbit press conference. "We needed to unload our Progress...we pulled out the fresh fruit, the oranges, the mail we got from home, and it gave us quite a lift after the memorial service."

When the shuttle comes visiting (below, in February 2001), the station's census goes up (above, during the STS-100 mission), and so does the workload.

The American astronauts were forced to ask Tito to stay out of the U.S. modules. "We weren't upset with each other," says Jim Voss. "I was angry with NASA."

The *Columbia* accident has forced new difficulties on the international station partners. The station suddenly was missing its main supply ship, and perhaps inevitably, NASA and the Russian Space Agency sparred over which should bear the costs for additional Progress cargo flights. The discussions are still going on.

With the shuttles grounded, all but a few of the scientific investigations planned for the station are in limbo. Nearly half of the lab's experiment racks are empty, and no major research equipment will arrive until shuttle flights resume. Even with a restored shuttle pipeline, it will be years before enough lab space and crew time are available to undertake the full research program intended for the station.

Meanwhile, the station astronauts continue their own informal experiment in living. If and when the crew size is expanded, more structured psychological studies will be able to explore the dynamics of large, multinational crews. Dan Bursch worries that we haven't yet found the magic number: "Three is a challenge for a long-duration crew. Five or six would help ease any personality conflicts." Sergei Krikalev agrees. "That's why we are flying a test bed. I think the smart thing to do would be to test different crew sizes in orbit now.... Then we can say which is better."

It's one of the many unfinished experiments on the station—and for astronauts hoping to one day live on the moon or Mars, perhaps the most important of all.

THE 30 BILLION *Dollar Man*

SEDDIK BELYAMANI KNOWS HOW TO MOVE THE METAL.

by Bill Sweetman

The contract had been negotiated down to the last comma. It covered the sale of 18 Boeing 767s—"A big deal," as Seddik Belyamani, Boeing's legendary salesman, puts it, talking quietly on a recent Saturday in the comfortable Bellevue Club in a Seattle suburb.

"We were staying across the street from the airline. At noon we walk over, saying that we'll sign and be back for lunch at one o'clock." In the airline's boardroom, all appeared to be going swimmingly: "I pick up my pen—it's a nice Boeing pen, the guy from contracts makes sure that the ink works—and I say, 'Shall we go?' The chairman

The master salesman, perched in an engine cowling of Boeing's biggest twin-engine heavy. The full-scale 777 will soon be delivered to Air France.

PHIL SCHOFIELD

BOEING

Turning over the keys to a new Boeing 737, the multilingual Belyamani (above, center) was first assigned to the French-speaking world, here in Niger…

says yes, so I sign, and I move the contract to him to sign."

That was when the chief financial officer said: "Just a minute, Mr. Chairman." The chairman put his pen down.

"That pen was down for eight hours," Belyamani says.

The airline didn't have a commitment from its bankers to finance the deal, the CFO told the chairman. "We want Boeing to give us an out, or commit to financing the airplanes themselves," Belyamani recalls the CFO saying. "I put my pen down and said 'We are not going to give you an out. We just cannot do that.' "

The airline execs left the room and came back at 1:30. "By that time we were starving," says Belyamani, who was stunned when the airline officials presented him with a new offer to buy six 767s, instead of 18. That's a different deal, Belyamani told them; "We'll be happy to come back in two weeks with a new proposal."

"My gut told me that they are going to buy these airplanes," Belyamani says, "and when your gut is right you take a firm stand." There was no Airbus sales team waiting in the wings, the market was strong, and Boeing could sell the airplanes elsewhere. The airline raised its offer to 12 airplanes, but Belyamani did not budge, increasingly convinced that the airline would make good on its first agreement.

Belyamani's gut was telling him something else: "It went on until six p.m. They didn't give us one piece of bread, zero, nothing." Convinced that this was a deliberate tactic, the Boeing team held their ground until the airline chairman, announcing that he was tired and going to play tennis, invited the famished and frustrated Boeing team home for dinner.

Belyamani told a colleague from the contracts division to bring the final agreement ("boxes and boxes") but carried in his own pocket a handwritten letter curtly revoking the original offer. ("Sometimes it helps to let your steam off," he says.) At the house, "the chairman looks at me and he says: 'Now then…' "

Belyamani said nothing. "I put my hand on my mouth"—a gesture that reminds him not to talk, he explains.

The next thing the chairman said was "Let's sign."

Says Belyamani: "If I had said one word, if I had said 'Now what is the problem, Mr. Chairman?' " the chairman would have seized the opening and Boeing would have had to restart the negotiation. "The moral of the story," Belyamani says, "is that there is a real person that signs the contract, not a computer, not an Excel spreadsheet."

"I could tell you that I was fascinated with aviation from the age of five, but it wouldn't be true," Belyamani says with the slightest hint of an accent, partly from his upbringing in Morocco, where he was knighted twice by successive rulers, and also from his education in Toulouse, France, home of Boeing's arch-rival, Airbus.

Bent on a career in electrical engineering building hi-fi systems, he was led by France's education track into aeronautical engineering. In 1967 he returned to Morocco to join Royal Air Maroc, the nation's international flag carrier, and in 1970 became vice president of maintenance. But after having lived in France it was hard to settle there.

After a year in Seattle overseeing the delivery of Royal Air Maroc's first Boeing 727-200, Belyamani attended the Massachusetts Institute of Technology, where he developed mathematical models to predict the performance of an airline's route network and earned a master's degree. He took those math skills to Eastern Air Lines and didn't like what he saw: After comparing Eastern's fleet and routes to those of arch-rival Delta, he recalls, "I got bad vibes and called friends at Boeing." Were there any openings, he asked?

In 1974, Belyamani was hired as an airline analyst in Seattle, his primary job being to back up the salesmen in the field. He soon got noticed. "We had a 747 that we were selling to an airline in Africa," he says. "Everything was going smoothly until three months before delivery, and we found that the International Monetary Fund had imposed restric-

ALASTAIR T. GARDINER

tions on their foreign debt and they couldn't pay for the airplane." If there is one thing airplane manufacturers hate, it's a "white tail"—a completed airplane with no customer and no airline livery.

"We tried to get hold of the airline's chief financial officer, but the guy was never there," Belyamani recalls. "I got fed up." Following a quick inquiry to the U.S. Embassy, the 36-year-old mid-level manager telephoned the president–not of the airline, of the *country*. "Sir," he said, "I need to speak to your minister of finance." Two minutes later, the minister called Belyamani. The sale was back on. As it progressed, "everything went wrong that you could think of," he says, but the 747 got delivered.

In the early 1980s Belyamani left Seattle and went into the field to sell. Fluent in Arabic and French (and some Spanish), he was assigned exclusively to French-speaking countries. "I was pigeonholed," he says. "I think that they forgot that I spoke English." Frank Shrontz, then the company's vice president of sales, moved Belyamani into Boeing's biggest markets, and over the next two decades he became its top salesman, retiring in mid-2002 with $30 billion in sales to his credit.

Being one of Boeing's sales representatives involves travel—lots of it. At one time, Belyamani was on the road for 200 days out of the year, inspiring the classic: "I sat down to family dinner one evening and my wife asked me what I was looking for. I realized I was reaching for my seat belt." Airline sales staffs worldwide know the joke and its author.

The people who sell large airliners don't make up a large group, and they all know one another well. They move around but stay in the industry. "It's a big family of people who have known each other for years," Belyamani says.

Where there once were a half-dozen or so companies building jet airliners of 100 seats or more, only Boeing and Airbus survive. Boeing normally has between 60 and 70 salespeople in the field; Airbus a similar number.

"What's special is that there are only two of us," notes Airbus' vice president for Middle East sales, Abdellah Sbai. (Coincidentally, Sbai, a rising star at his company, is also Moroccan-born and also entered the business via Toulouse and Royal Air Maroc.) "There's always a winner and a loser at the end, and you always lose against the same competitor," he says.

At a personal level, the rivalry between the two giant manufacturers has been friendly. Says Sbai: "We meet in the same waiting rooms and we pass them in the corridors." But they never talk business, he adds.

During a hard-fought sales campaign in Australia, John Leahy, Airbus' chief commercial officer, invited him aboard an Airbus A320 in Sydney. "We toasted each other, each of us thinking, *Here's to your loss*," says Belyamani. Boeing prevailed, and Leahy later told Belyamani that he'd send him a photo of their meeting when he was in a better mood.

BOEING

...and in Cameroon (above), before Boeing moved him up to bigger markets and airplanes like the 747s (top).

The sales campaign—Belyamani calls it "an obstacle course with people throwing things at you"—never goes the same way twice, though it starts when an airline indicates that it's ready to buy airplanes and ends when the manufacturer's representative and the airline CEO sign the contract. And not a second sooner, as Belyamani has learned when airlines balked at the last instant. That kind of last-minute crunch is unusual; most airlines push for concessions from the first day.

After the initial indication of interest, it's the manufacturer's turn. Like all salesmen, those selling airplanes strive to make deals that retain as much profit as possible for the company. The salesman makes the first offer, which is calibrated to appeal to the airline without giving away the store. "If you've done your homework properly, you've talked to the decision makers, the head of the department that analyzes this stuff, the VP of operations, the maintenance guys, and they've told you what they would like to see," says Belyamani. "So you

go in with your proposal. The next day they tell you you're way off the mark, you're never going to win. It depends on how aggressive their negotiating style is. Some of them will tell you how much you're off, particularly if they've made a gut decision to buy your airplane."

In rare cases, the negotiations are brief; some products sell themselves. "The most beautiful campaign we had, years ago, was Air Mauritius," Belyamani recalls. In it, the 767 went head to head with Airbus' A310. "They wanted to fly from Mauritius to London, and the A310 can't make it. End of speech. Today you have the A320 and the 737-800 and they're close enough that you're arguing about seats and price."

Often the negotiations—arguing over seats and price—take a long time, and winning a campaign requires patience. "The [Boeing] 777 has some advantages that we can quantify over the [Airbus] A340. You have to start selling that story two years before the decision. You can't come in at the last minute and say, 'My airplane's more expensive, but it has all of these advantages, it carries more cargo, it burns less fuel.' "

BOEING

Royal circles: Jordan's late King Hussein (right), an active pilot, listened as Belyamani made a point.

Analysts and marketing people provide the salesmen with technical data and information that make the airplane look as good as possible. "One of the biggest areas of tweaking is seats," Belyamani says. A good analyst will add seats to his airplane knowing the airplane probably would never go out the door that way; it's just for the seat-miles game. "There are tricks: the number of galleys, number of lavatories, number of closets." The competitor claims an equal number of closets and hopes the airline won't notice that they're smaller. "We measure the closets by rod length," Belyamani says, pointing out that it's the number of hangers you can fit in all the closets that determines total storage capacity. And if the seating layout has no cross-aisle, that's a dead giveaway that the salesman is being less than realistic. "In a twin-aisle airplane you need a cross-aisle somewhere in the middle of the airplane," says Belyamani. Without it, there will be traffic jams and meal carts in gridlock.

But ultimately, the salesman's most effective tool is an intimate knowledge of the airline and the people who make it run. "The litmus test of having a close relationship with an airline customer is when you can feel free to call the CEO at home, talk to his or her spouse, and get valuable advice on where you stand," Belyamani says. "The ultimate is when the CEO starts confiding in you about his personal life." That doesn't happen very often, he adds.

For a field salesman, schmoozing the CEO is not enough. "You have to go two or three levels below the head," says Belyamani. "There have been cases—it hasn't just happened to me—where there's a little guy who lives in the corner office and nobody paid attention to him because he was a number-cruncher, and they're dealing with the big guys. Lo and behold, two or three years later you find that the little guy in the corner office is the CEO."

Belyamani says the worst sales prospects were the cases in which he didn't know where he stood or when he didn't have time to build a relationship with a buyer. "You can tell there's no electricity—'Thank you very much for your offer, we'll consider it.' " he says. "When you don't have a dialogue, you sense that you're losing. They didn't ask any questions, they didn't challenge my numbers. It's bad.

"Sometimes it works to their advantage to be in disarray, because they're confusing the hell out of you," leaving the salesman guessing whether the airline is roiling with internal dissension or putting on an act to beat down the price. Belyamani's advice in that situation: Stall. "You try to convince them that there's no rush, that the delivery positions will be there if they make a decision two or three months from now."

OLIVER BRUNKE

An Air Mauritius deal pitted the Boeing 767 against Airbus' A310—a "beautiful campaign," Belyamani says.


IVAN RODRIGUEZ

Airbus A330, main cabin, view aft: Seats 'n' aisles ('n' closets) is a game of inches played by both sides.

Among the customers Belyamani has worked with, business styles vary. "It's hard to generalize," he says. "The Japanese are tough negotiators. They operate by consensus. There's no real decision maker; it makes it hard to work. When they reach an agreement they live up to it, to the letter. They're not really hagglers, but they know what they want and they get it."

Middle Eastern customers "believe in win-lose," says Belyamani. "They're not satisfied until they feel that you have given everything." But they are not as obsessed with numbers as the European and U.S. airlines, which tend to "conduct their negotiations with data. They say 'Your airplane has a seat-mile cost of X and it needs to be Y for it to work for us.' It's a more logical style. You may believe it or not, but at least you've started with a rational foundation."

In dealing with foreign customers, says Belyamani, "if you speak to someone in their own language, it establishes a bond." Even if you conduct business in English, the jokes and pleasantries may be in Arabic, he says. Belyamani's multi-lingual talents have served him well.


BOEING

My customer, my friend: Belyamani with Tan Sri Tajudin Ramli, Malaysia Airlines chairman.

Another challenge in dealing with foreign customers is government involvement, which can make decisions drag on. "The Saudi order [after the first Gulf War] took at least two years," Belyamani says. "At one time there wasn't a single person at Boeing who knew the whole transaction."

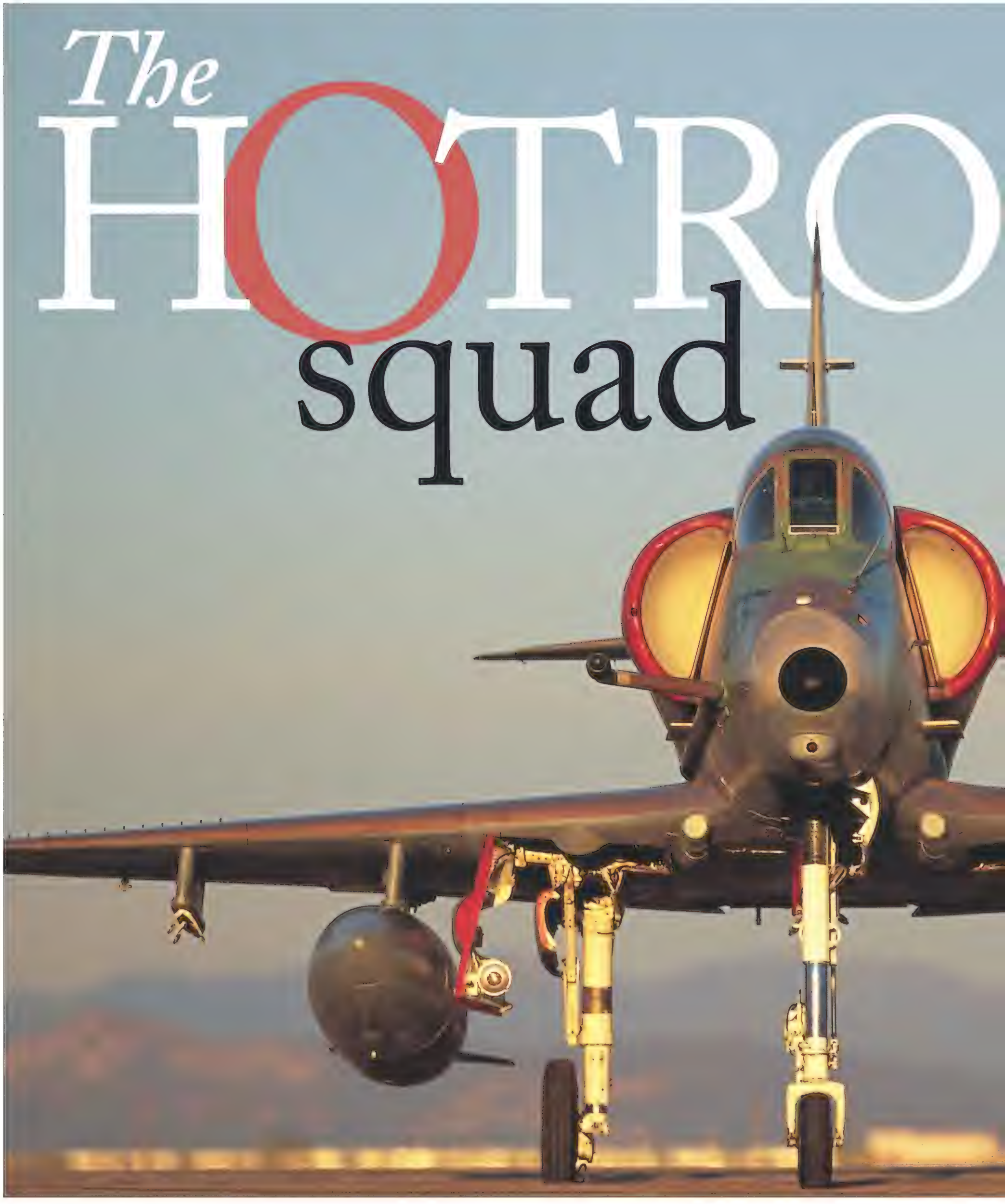
More and more airlines have been privatized by their former government owners, and Belyamani hastens to point out that the decline of government ownership has led to a decline in incidents of bribery. "The U.S. has a very stiff law [the Foreign Corrupt Practices Act], and I'm not interested in going to jail. If somebody brings it up, you say we can't do it, it's against the law. We've lost campaigns like that, but it's rare now."

What attributes for surviving and thriving in this business can't be taught? "Common sense, a self-starter, integrity," says Belyamani. He fervently believes that credibility is an aircraft salesman's most important asset, and he has devised his own credibility scoring system: "If the customer wants to know something and you respond fast, you score. But if you're wrong and it's discovered that you're wrong, then your credibility goes down by a factor of four. If you accidentally get something wrong, and your customer doesn't notice and you call immediately to correct it, your credibility goes up three times."

Optimism is also vital, he believes, keeping you going after you lose the very campaign you worked on hardest. "The first losing campaigns were a bit tough," says Airbus' Sbai. "You have to take a long-term view: You can lose and win again later."

Belyamani, who still consults for Boeing, believes that some people think that selling something as big and expensive as airliners must be different from other sales jobs. "It isn't," he says. "In a lot of ways, the same principles apply to selling a washing machine."

The HOTROD squad



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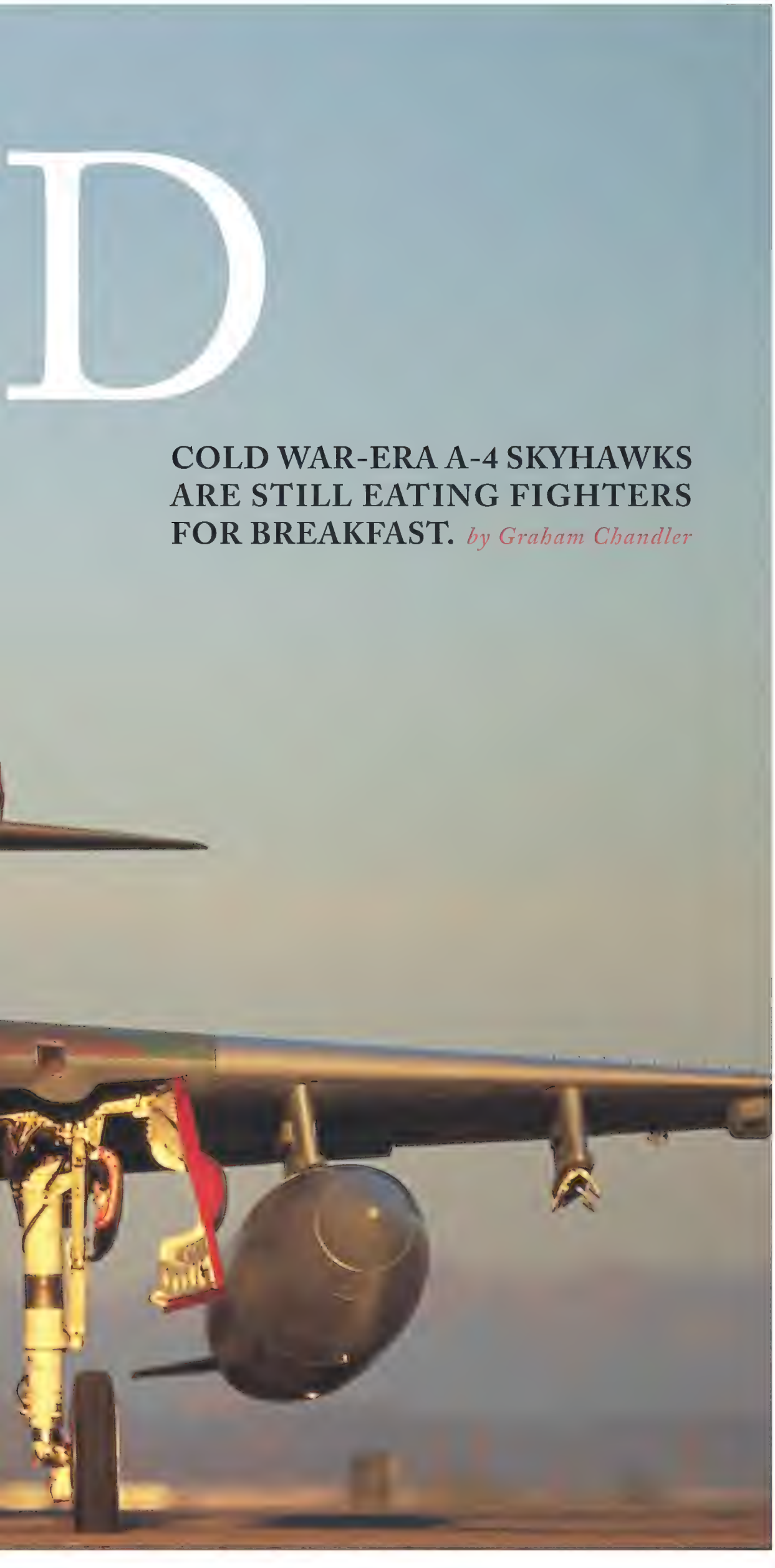
COLD WAR-ERA A-4 SKYHAWKS ARE STILL EATING FIGHTERS FOR BREAKFAST.

by Graham Chandler



CHAD SLATTERY

"EVERY SINGLE PERSON I'VE EVER FOUGHT IN ONE OF THESE AIRPLANES HAS DIED THE FIRST TIME I FOUGHT HIM. Every… single…one." Randy Clark brandishes a model of the A-4 Skyhawk and tells me how the half-century-old design can whup far newer aircraft: F/A-18 Hornets, F-14 Tomcats—maybe someday even F/A-22 Raptors and F-35 Joint Strike Fighters.

I need no convincing. In the 1970s, I'd flown in an A-4 variant, the two-seat TA-4J, at the U.S. Naval Test Pilot School at Maryland's Patuxent River base. As an engineering student learning how to size up a fighter's combat performance, I'd experienced first-hand how this machine could out-hassle pretty well anything in the sky.

Clark and I are talking in the ready room. The chalkboard is scribbled with arrows and altitudes and trajectories. Pilots wander in and out, wearing khaki flying suits with wings and nicknames like "Booger" and "Decoy." Some gather in groups, spreading fingers and tilting hands in mock air combat.

Outside, where the temperature has just exceeded 100 for the umpteenth time this year, seven 30-year-old Skyhawks in green and brown camouflage stand on the flightline. But this is not a military base. The Phoenix facility is the headquarters of Advanced Training Systems International, a private company that sends A-4s and A-4 pilots to military bases to provide "red air"—service as sparring partners for Navy and Air Force pilots.

To train as a lethal force, a military pilot needs to practice coming up against an "enemy" that is as realistic as possible. So a red-air aggressor will, for example, emulate a North Korean MiG-29 pilot who hides in a valley out of radar detectability, then pops up unexpectedly to attack. This "dissimilar aircraft combat training" is part of the five to eight weeks of air warfare training that all U.S. Navy air crews, no matter which aircraft they're assigned to, must get before each combat deployment.

The Navy retired the A-4 last summer. Today, a flock repose at the military's Davis-Monthan boneyard in Arizona.

RICHARD VANDER MEULEN (4)

> "IF AN A-4 GETS THEM OFF THEIR GAME PLAN AND FIGHTS THE WAY IT PREFERS, THE OTHER PILOTS WON'T LEAVE HAPPY."

Traditionally, the Navy has provided its own adversary aircraft: F-5s at Naval Air Station Fallon in Nevada, F/A-18s at Key West, Florida, A-4s on Vieques, an island off Puerto Rico. But last year the U.S. government closed the Vieques facility. Consequently, the adversary squadron there, VC-8, was decommissioned, and the A-4s were retired.

Though the Navy continued to provide most of its own adversary aircraft, the A-4 retirement left the service short. Spotting the void, Larry "Hoss" Pearson, a combat veteran and one-time commander of the Navy's Blue Angels, and Jon "Orbit" McBride, a former space shuttle pilot, decided to form a company to supply red-air aircraft and pilots to military bases that needed them.

The entrepreneurs went shopping for some good used combat aircraft. Sukhoi 27s would have been "bloody perfect for the adversary role," says Clark, but, given the difficulty of getting spare parts, a potential maintenance nightmare. Then, says McBride, he and his partner heard about "some nice, low-time" A-4s for sale in Israel. Two years later—including six months to get the Department of State's blessing—ATSI had 13 A-4s on its apron.

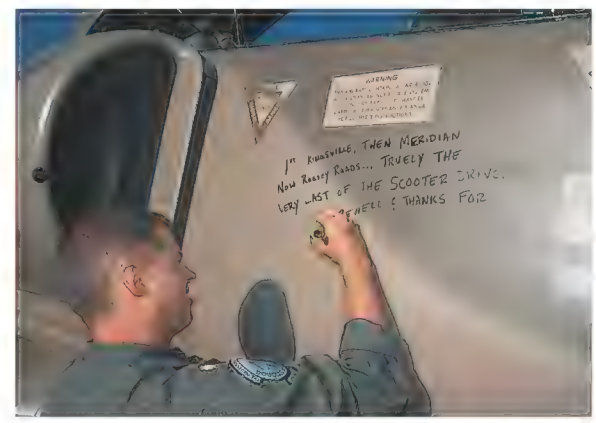
At first glance, A-4s might seem too old to fight younger aircraft. Says Clark, then the company's director of marketing: "The biggest challenge in going up against newer planes like the Hornet is to get close enough for us to see them, because they usually have the superior radars and missiles" and

The Skyhawk's landing gear struts were made tall so large stores—bombs, rockets, fuel tanks—could fit under the wings.

can see the A-4s and fire on them first.

But if a crafty pilot can use the Skyhawk's famed maneuverability to gain that proximity, "the A-4 is a great opposition platform because it is totally dissimilar to the Tomcat or Hornet; it fights totally different," says Roger "Rock" Pyle, recently retired from the position of adversary instructor at the VFC-13 squadron at the Fallon base in Nevada. He adds: "If an A-4 gets [them] off their game plan and fights in a way the A-4 prefers—slower, in the phone booth—then the F-14 and F-18 pilots don't often come away happy."

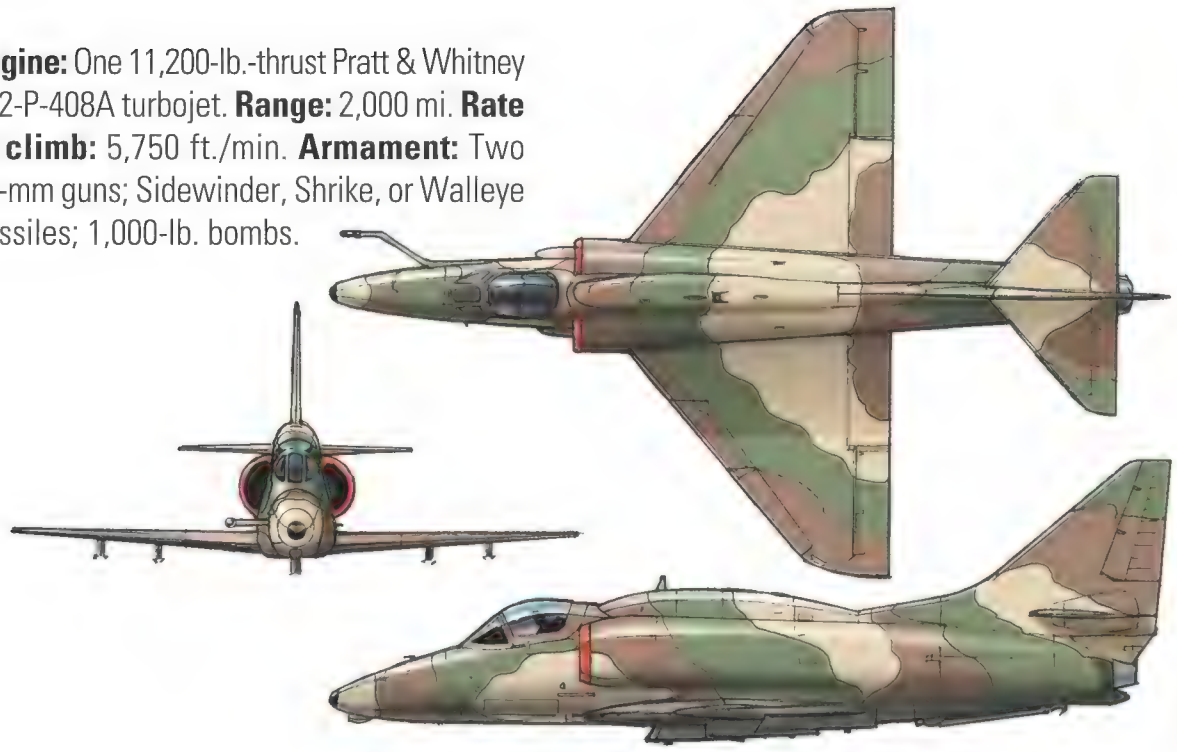
After the A-4s arrived at Davis-Monthan (left), VC-8 ops officer Mike Eberhardt handled the traditional sign-off, penning a note of affection.



Curious as to how a Hornet driver might react to those comments, I later talk to Captain Brehn Eichel, who directed a recent Exercise Maple Flag, an annual mock war in which pilots from half a dozen countries fly F/A-18s and other combat aircraft against red-air adversaries; Eichel had faced ATSI's A-4s in the early summer of 2002 at Cold Lake, Canada. "No self-respecting fighter pilot will say, 'Yeah, they kicked my ass!' " he laughs. "But we expected to be able to out-power, out-climb, and out-turn them, and they kinda humbled a few guys. The A-4 will get in your shorts if you let it."

Eichel recounts the humbling specifics of the engagement: "With the F-18 you can pull a whole lot of G right away, but the wing gets dirtied up"—at high Gs, the F/A-18's computer deploys the flaps on the wing's leading and trailing edges to avoid stalling; that increases drag, causing the aircraft to lose energy. "It's harder to regain that

Engine: One 11,200-lb.-thrust Pratt & Whitney J52-P-408A turbojet. **Range:** 2,000 mi. **Rate of climb:** 5,750 ft./min. **Armament:** Two 20-mm guns; Sidewinder, Shrike, or Walleye missiles; 1,000-lb. bombs.



HARRY WHITVER

energy," continues Eichel, "so that's where the A-4 was quite impressive—its energy-sustaining capabilities." He says that a brief moment can make a major difference. "All you need to do is take them for granted or not pick them up on your radar or not see them, because all it takes is one heat-seeking missile, regardless of how low-tech it is, to wreck your day."

Now ATSI's director of combat flight training, John Marksbury claims the most A-4 hours—over 5,000.

CHAD SLATTERY (2)

Red air is the latest of many roles the A-4 has played since it first flew 50 years ago, on June 22, 1954. Designed by the brilliant Douglas Aircraft engineer Ed Heinemann, the aircraft was originally conceived to respond to the Navy's request for a super-cheap, super-lightweight jet interceptor that could be fielded against the Soviets' MiG-15s. In January 1952 Heinemann arrived in Washington to sell his design to Navy brass, only to be told that the service had dropped its interceptor requirement. But in the audience for Heinemann's presentation was legendary naval aviator Admiral Apollo Soucek, and he loved the design's light weight and great maneuverability.

Since the Navy needed a more efficient jet replacement for its piston-engine Douglas A-1 Skyraiders, Soucek asked Heinemann if he could transform his design into an attack airplane—keeping it under 30,000 pounds and giving it a top speed of at least 500 mph and a combat radius of 345 miles. Scant weeks later Heinemann was back with a new design. It came in at less than half the specified weight, and it exceeded the stipulated combat radius by 115 miles, and the top speed by 100 mph. In six months Douglas had a contract for two prototypes.

The Skyhawk design team achieved the bantam weight by shaving pounds, even ounces, wherever they looked—ejection seat, avionics, hydraulics. Their methods were similar to those used in designing race cars, and the aircraft picked up the nickname Heinemann's Hot Rod. (Later, its crisp maneuverability had air crew calling it the Scooter.) A key attraction was the the delta-shaped wing : The tiny span of 27 feet made the aircraft a smaller target. The compactness also did away with the need to make the wings foldable for carrier operations.

ATSI's Mac McMakin removes rivets before fitting a left aileron with a new skin, while Nathan Rose (above) tightens the first-stage lubrication lines on an A-4's turbojet.

CHAD SLATTERY (3)

> USING THE METHODS OF RACING CAR DESIGNERS, THE SKYHAWK TEAM SHAVED OUNCES WHEREVER THEY LOOKED.

This Douglas-designed patch boasts of the A-4's ability to pounce on enemies from high altitudes. A-4s easily reach 50,000 feet.

Jon McBride (right) co-founded ATSI after a career as a shuttle astronaut.

Heinemann's design proved hugely popular: Eventually 2,960 A-4s in 21 models were delivered. The last left the factory in 1979, and by then, the Skyhawk had had the longest production run of any U.S. combat aircraft.

One of its early missions was the delivery of nuclear bombs. Retired Marine Major Art Padios, who flew simulated deliveries out of Japan in the early 1960s, recalls: "Once you got into the [enemy's] radar coverage, you'd go down on the deck. We were so small, and down at 50 feet traveling at 500 knots [575 mph], there wasn't anybody that was going to find us." There was one potential problem: "I had several targets [to hit] with 1.1 megatons and wasn't sure I could outfly the fireball—it's four miles in diameter!"

Had Nikita Krushchev called JFK's bluff during the October 1962 Cuban Missile Crisis, Padios might have found out. In that show of might, Skyhawks were catapulted off the USS *Enterprise*, *Independence*, *Essex*, and *Randolph* to show the flag at various locations near the island. Deployed to Cuba to support a potential invasion, Padios flew A-4s from the U.S. base at Guantanamo Bay. "They were practice close air support missions, staying on our side of the fence," he says.

Out of the Cuban experience came a startling wakeup call: The A-4 drivers realized that in the course of taking out the sites of the nuclear missiles that had precipitated the crisis, they would be vulnerable to surface-to-air missiles. "They took us to [the California base] China Lake to develop maneuvers specifically for flak suppression and how to take out SAM sites," recalls Padios. "It evolved into the Iron Hand role in Vietnam."

Iron Hand was one of the A-4's riskiest missions. "We tried to be just high enough to get the SAM search radar to spot us but not so high that we couldn't evade quickly by diving for the deck," recalls Al Carpenter, veteran of two combat cruises with Navy Attack Squadron 72. The pilots dove to quickly get out of the SAM site's radar "cone" and get a missile off (usually a Shrike). But the Shrike needed to be in that cone to home in on the SAM site, so the A-4 pilots developed a novel delivery technique: "We would aim directly at the site, then pull the nose up about 15 degrees before firing our missiles," Carpenter says. "Sort of like shooting baskets." Once inside the cone, the Shrike picked up on the SAM site's radar to home in for the kill.

For the Marines in Vietnam, Skyhawks were the backbone of close air support. Operating from Chu Lai, just south of the Demilitarized Zone, the Marines at first used SATS, the Short Airfield Takeoff System, in which JATO (jet-assisted takeoff) bottles launched A-4s loaded with rockets and bombs off temporary aluminum runways. "We had a variety of targets," says Padios, though at first the pilots flew "mostly to support troop helicopters. We'd circle them as they went, and suppress [ground] fire with napalm, cannons, and bombs. A FAC [forward air controller] would run with us."

FACs loved the A-4, says Padios. During strike missions, "they wouldn't let anyone drop unless they could get them exactly on the run-in line. I've been in a stack with [F-8] Crusaders and [F-4] Phantoms, and one after the other the FAC would make them do a practice run, and if they couldn't get on the line exactly he would tell them to go away and wait

The popular TA-4 trainer has been bought by Brazil, Indonesia, Kuwait, New Zealand, Israel, and Singapore.

for the A-4s. We were so maneuverable that when we got abeam the target we could roll into 100 or 120 degrees of bank and *zap*, we're on the run-in line. The roll rate on that airplane was 720 degrees a second."

The FAC often flew an A-4 too: the two-seater variant. Former Marine FAC Bob Miecznikowski says a typical mission would start in Da Nang; the FACs would be assigned a particular area, such as the border between North Vietnam and Laos. "We flew initially with naval gunspotters in the rear seat," he says, but later the FAC aircraft would fly with two pilots. "The front-seat pilot would fly the aircraft while the rear-seater looked for targets and [guided] any aircraft during strike missions," he says. The FACs often had to knock out anti-aircraft sites that were defending against the main force.

As would be expected of an aircraft that has served in so many wars, tales of the A-4's survivability abound. Padios recalls escaping from North Vietnamese anti-aircraft fire that was "all black and white and orange balls bursting over my head." Not wanting to go through it, he "pulled off 8.5 Gs in a roll—and the rolling limit was only 3.5." The stress of the maneuver popped 60 of the aircraft's rivets.

> "AT 50,000 FEET, YOU'RE HARD TO SEE, AND YOUR ENERGY IS HIGH, SO YOU CAN DO VIRTUALLY ANYTHING YOU WANT COMING DOWNHILL."

(I've also experienced a high-G roll in an A-4, though unintentionally. At the Patuxent River school one afternoon, during a maneuvering stability lesson in a two-place TA-4J trainer, I was doing a hard pullup when one of the leading edge slats deployed—yes, just one—snapping the craft from 5.5 Gs into a totally unexpected 360-degree roll, which banged our heads hard on the canopy. Once the Gs were unloaded, the aircraft recovered nicely.)

After Vietnam, the A-4s flew in the Yom Kippur War, the Falklands War, and the first Gulf war. By the time it retired, the A-4 had equipped 51 front-line Navy and Marine squadrons and eight overseas military services. Its career included more major wars than any other U.S.-made combat aircraft.

Besides red-air service, ATSI provides combat training to foreign military pilots who have just earned their wings. Unlike red air, combat training is conducted at ATSI's own headquarters: the decommissioned Williams Road air base, outside Phoenix.

At the time of my visit, the students training at the school are from the United Arab Emirates. They are using the school's A-4s and A-4 simulators to transition to Block 60 F-16s, 80 of which will be delivered to their country by 2008.

As Randy Clark and I stroll out of the ready room, we pass UAE students sitting on the edge of their soft leather

chairs, listening to the morning flight briefings.

In the simulator room, I slide into the A-4's snug cockpit. "Fits like a sports car," Clark says, then goes on to explain the Skyhawk's unique combat advantages: "She's a high-subsonic airplane, and almost all engagements take place below 0.9 Mach."

I ask what advantage this gives.

Clark begins to explain, using his hands to help. In the next simulator, a student glances over. "If you go by my A-4 at 1.2 and I'm doing 0.9, I can turn around faster than you can," Clark says. "At 1.2 your turning radius is gonna be the state of Wyoming. My turning radius is very small. And if you held 1.2 you'd really get killed in a hurry. Because the missile that I launch at you by the time I get turned around is a Mach 3 missile, so you're not gonna outrun it."

Clark's eyes narrow. "It's going to get you.

"You have to slow down to my speed to get to a really good turning performance," he goes on. "Then you're coming to my fight. At 15,000 feet with a clean airplane, I can pull 6 Gs all day long until I run out of gas.

"And my speed also allows me some vertical penetration that would really get anybody's attention. We can go right up to 50,000 feet with impunity. Up there you're above the cons [contrails] and difficult to see. Your energy is high, so you can do virtually anything you want coming downhill."

And ATSI has heightened its Scooters' maneuverability. Gone are the guns and armor; the school flies the aircraft "clean"—no external bombs, rockets, or fuel tanks to create drag. The changes have moved the aircraft's center of gravity aft, boosting the pitch rate—important in air combat.

CHAD SLATTERY (2)

The Navy's Blue Angels flew A-4s from 1974 to 1986. These liveried examples are displayed at the National Museum of Naval Aviation in Pensacola, Florida.

The director of combat flight training is longtime A-4 vet John "Decoy" Marksbury. I ask him: Is there any airplane he'd choose over the A-4? "A newer version of it," he says.

Hard use of these 30-year-old aircraft can keep technicians on their toes. Out on ATSI's hangar floor, amid the woodsy smell of hydraulic fluid, workers in overalls climb around three A-4s, minus engines and tail sections. "Our maintenance program mirrors the U.S. Navy's," says Al Edmonson, a Navy veteran and ATSI's director of maintenance. "We do most everything in-house."

I ask him about finding spares. He points. "See that room over there? I've got five guys whose sole purpose is to find parts."

Help may arrive soon: ATSI is negotiating to buy 17 more A-4s and a massive parts package from New Zealand. The deal includes a bonus: APG-66 radars and head-up cockpit displays—both of which may make the 50-year-old design an even more formidable adversary for honing the skills of pilots preparing for combat.

A new life: It's morning, and crews are readying TA-4s for air combat training sorties at ATSI.

RICHARD VANDER MEULEN

How Things Work:

Safer Fuel

by Damond Benningfield

When TWA flight 800 exploded off the coast of Long Island in 1996, many people suspected a terrorist bomb or missile. Federal investigators, however, focused on a more mundane source for the catastrophe: the Boeing 747's center fuel tank.

Although the exact cause remains unknown, in 1997 the National Transportation Safety Board concluded that an electrical spark ignited a mixture of fuel vapor and air in the tank, setting off an explosion that destroyed the airliner and killed all 230 people on board.

In the years since, the Federal Aviation Administration has addressed half of the explosive equation—sources of sparks or other ignition hazards—by requiring airlines to provide better insulation, move wiring, inspect fuel pumps, and take other actions.

Later this year, the FAA plans to order reductions in the flammability of gases that float in the void above Jet A fuel in airliner tanks. Airlines and manufacturers will be able to meet the requirement by using systems based on a prototype developed by the FAA—an onboard inert-gas generation system (OBIGGS), which replaces much of the air in a fuel tank with nitrogen, a gas that does not support combustion. The technology "will virtually eliminate the possibility of future fuel tank explosions," FAA Administrator Marion Blakey said in February when announcing the agency's plans to recommend that 3,800 Boeing and Airbus airliners be fitted with inerting technology.

The military has used inerting systems for decades to reduce the chance of fire resulting from bullet or shrapnel impacts. The F-16, for example, injects Halon 1301 gas, a common fire suppression chemical, into its tanks, while the giant C-5 uses liquid nitrogen, which is denser than its gaseous form (and thus requires less storage space) and which can easily be warmed to expand into a gas. But these systems are expensive and heavy, and require extensive ground support, making them impractical for most commercial aircraft.

Engineers have made a breakthrough in the last couple of years by "challenging assumptions," says John Hickey, director of the FAA's aircraft certification service. "We thought you had to get the oxygen down to about nine percent, which is what the military uses. But we looked at 12 percent, and the tests said that it works."

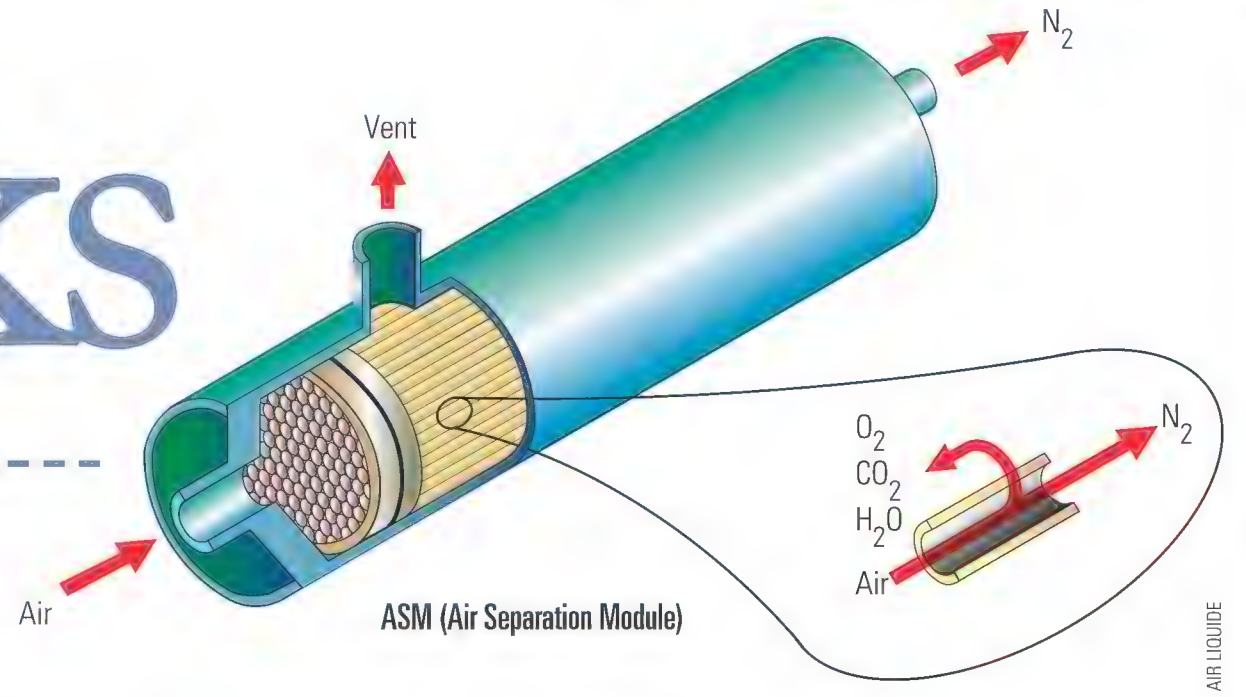
With a lower percentage of nitrogen required, a team led by FAA engineer Ivor Thomas was able to develop an OBIGGS prototype that weighs less than 200 pounds—about one-tenth what a typical military system weighs—and requires no compressors or other moving parts.

The system uses "a small amount" of air from the engines, Hickey says.

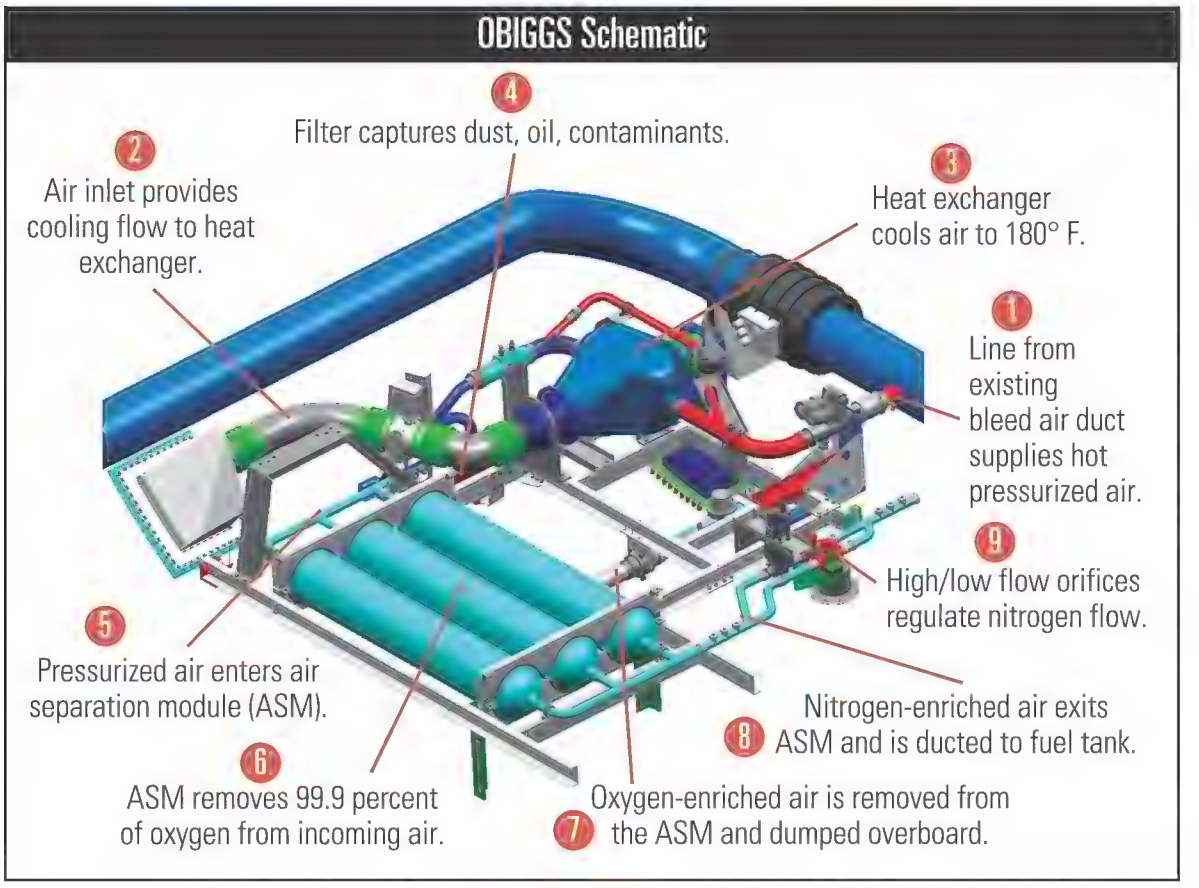
Installed in the cargo hold, the FAA's onboard inert-gas generation system prototype made nine test flights in an Airbus A320 last year.

FAA

Tanks



AIR LIQUIDE



FAA

The air flows through a 1.5-inch-diameter stainless steel pipe into a heat exchanger, which gulps air from outside the aircraft to cool the bleed air from about 350 degrees Fahrenheit to 180 degrees, the temperature at which the system separates nitrogen and oxygen most efficiently.

The cooled air passes through a filter that removes all but the tiniest particles of dirt and oil, then enters the heart of the system, the air separation module. The ASM consists of three parallel aluminum tubes; each is about 40 inches long and eight inches in diameter. The tubes are filled with bundled rows of permeable fibers, each fiber about the width of a human hair. "It looks a lot like a rope," Thomas says of the bundles, with "millions" of individual fibers lined up in each tube.

The pressurized air that enters the ASM tubes consists of 78 percent nitrogen, 21 percent oxygen, and one percent trace elements—the same distribution as the air we breathe. As air enters the hollow interior of each fiber, oxygen and trace gases (and a small amount of nitrogen) permeate through the fiber walls and are vented and dumped overboard. As a result, the air exiting the far end of the fiber—and ultimately the ASM—consists of about 99.9 percent nitrogen.

Because aircraft fuel tanks are vented to allow for equalization of pressure at different altitudes, the nitrogen must be constantly fed into the tanks to displace the outside air that freely enters. Pressure valves regulate the flow so that the fuel tank isn't over-filled, and FAA ground tests of the prototype showed that the nitrogen is quickly distributed throughout the tank, so no fans are needed to circulate the gas. The system operates in two modes: low-flow and high-flow. When the airplane has taken off, instruments signal OBIGGS, and the system enters the low-flow mode. OBIGGS remains in that mode through climb and cruise. Since air pressure is much lower at cruising altitudes, the system can displace all but two or three percent of the fuel tank's oxygen.

Conversely, during descent, air pressure rises, so more outside air flows into the tank, increasing the oxygen content. To compensate, OBIGGS goes into high-flow mode, pumping in additional nitrogen at a faster rate. Even so, the concentration of oxygen jumps from a few percent at cruising altitude to between nine and 12 percent at landing.

Airlines and manufacturers are not required to adopt the FAA prototype, Hickey notes. Boeing recently announced it will use its own system, which is based on the FAA prototype, and has committed to deploying it on the new 7E7. According to Hickey, FAA regulations probably will require installation of some fuel-inerting technology on all large jets in the U.S. fleet within five to seven years, at which point—in FAA's Blakey's words—"we can close the door on fuel tank explosions."

Saturn's Deep, Dark Secret

What will we find on the ringed planet's largest moon?

by Craig Mellow

Most of us probably feel that we spend long, tedious intervals in the shadows awaiting brief moments of glory.

But spare a thought for the European Space Agency's Huygens planetary probe. After a seven-year cruise through space, the 700-pound disk, stuffed with electronic instruments, will spend as little as three minutes on the surface of Titan, the largest moon of Saturn. Then it will either sink beneath a burbling methane ocean or be abandoned in frozen Titanic wastes forevermore. And that's if everything goes well.

Yet Huygens and its ground controllers in the German suburb of Darmstadt will in those three minutes see what no one has seen before. Titan, which is larger than Mercury and almost half the size of Earth, is surrounded by a dense gaseous atmosphere that has kept its surface hidden—from the Voyager probes, which flew by in 1980 and '81; from the Hubble Space Telescope, which measured the moon's surface reflectivity in 1994; and from the cloud-penetrating radar of the Arecibo Observatory in Puerto Rico, which in 2001 and 2002 detected glints from Titan's radar-reflective areas. To know the surface of Titan, scientists must send an observer to descend beneath the atmosphere. ESA's Huygenauts don't even know if their vessel will land on a hard surface or liquid; they figure the chances for either at 50-50.

What they do know is that Titan's atmosphere, which Huygens will study for a whole two and a half hours before its finale on the surface, is intriguingly like Earth's probably was four billion years ago, when fledgling organic compounds like methane first began to vary the choking miasma of nitrogen. Life as we know it cannot evolve on Titan, thanks to average temperatures of –289 degrees Fahrenheit. But the great moon is "a unique laboratory for studying the pre-biotic soup," in the loving phrase of Jean-Pierre Lebreton, the 54-year-old French physicist who has given most of his working life to Huygens and is ESA's top scientist on the project. "There's a large list of hydrocarbon molecules, indicating something very strange and complex is going on in the atmosphere and on the surface," he says. "Basic information about how life was created that is erased on Earth may be frozen for us to study on Titan."

The Huygens project—named for Christiaan Huygens, the Dutch astronomer who in 1655 discovered Titan—is something of a pioneer back on Earth too. It is Europe's farthest stab by far into the universe. It is also the first spacecraft of any country to attempt a landing—hairsplitters would say an "impact"—in the outer solar system.

"By the time we get the first pictures, we will have either succeeded spectacularly or failed spectacularly." So concludes David Salt, one of two British techies minding Huygens' so-far quiescent bank of computer monitors in a bunker-like control room in the Darmstadt basement. Either way, it will be too late to do anything about it. With Huygens 80 light-minutes from Earth (compared to nine for the Mars landers recently in the news), a round-trip radio signal, even assuming it penetrated the Titanic haze, would take longer than Huygens' planned 150-

Titan's atmosphere deceived scientists into believing it was the largest moon in the solar system until Voyager showed its true size (smaller than Jupiter's Ganymede). But it will be Cassini-Huygens that reveals Titan's surface.

JPL

ESA

minute plunge through the atmosphere. The little craft—all of eight feet in diameter and looking Star Wars-adorable hunkered behind a cap-like heat shield—will be alone in the impenetrable fog of strange and complex hydrocarbons.

At about 200 miles above Titan's surface, the heat shield will brake the craft from 12,400 mph to 870 mph in less than two minutes. Sensing the reduced speed, accelerometers on board should trigger the release of the first of three parachutes, meant to slow the craft to about 12 mph so its impact with the surface will be survivable. When the first chute deploys and the shell is jettisoned, the science instruments kick in, and the distilled genius of another pint-size explorer—the European Space Agency, which figures its budget at six percent of NASA's—goes to work.

ESA has had help. Plenty of American know-how is at work on Huygens too. For one thing, the probe is hitching a ride to Saturn on a NASA spacecraft named Cassini (after Renaissance Italian skywatcher Gian Domenico Cassini, who discovered one of the gaps in Saturn's rings). Cassini will begin to orbit Saturn on July 1 and, sweeping by Titan with its infrared camera and radar, will upstage Huygens with the first glimpses of the moon's surface. Six and a half months later, Cassini will drop Huygens off to visit Titan, relay (it is hoped) Huygens' data feeds, then head off on its own four-year tour of the ringed planet.

Titanists have theorized, perhaps wishfully, that Huygens will break out of clouds at 60,000 feet.

Huygens carries a transatlantic suite of instruments. An Aerosol Collector and Pyrolyzer, built in Paris, will grab samples of Titan's atmosphere during descent, vaporize them, and feed the results for analysis to a spectrometer constructed at NASA's Goddard Space Flight Center in Maryland. The Italian-made Huygens Atmospheric Instrument, which senses lightning and other electrical activity in the moon's sky, works with a Descent Imager and Spectral Radiometer (that is to say, a camera and radiation sensor), contributed by the University of Arizona.

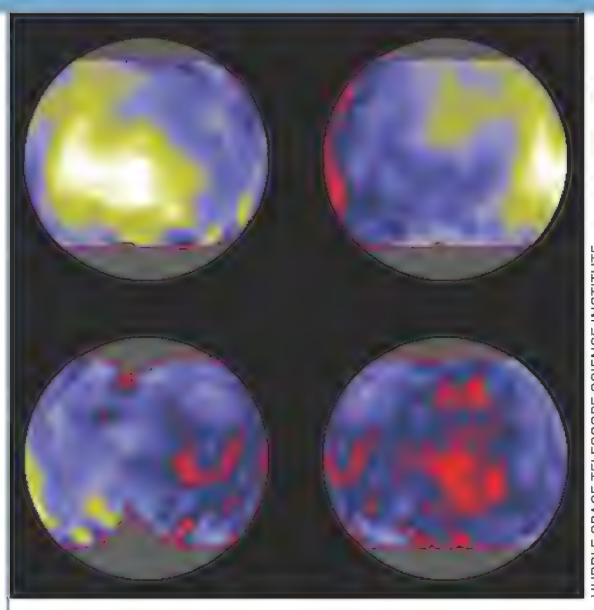
Cassini-Huygens scientists insist that their real purpose will be fulfilled above Titan's surface, as the instruments log chemistry, electricity, winds, and the rest of it. "The main mission is going through the atmosphere," Lebreton says. "The rest is bonus, if we get anything back."

But Louis Friedman, executive director of the Planetary Society, lets the cat out of the bag when he reveals what his California-based space advocacy group and the growing community of Internet space watchers want from Huygens. "If we could ever get an image from close to the surface," he says, "that would be just awesome."

Astronomers have argued about the surface of Titan since the 1970s when they found evidence of a thick cloud deck in its atmosphere. Data from the Voyager spacecraft in 1980 spurred the theory that Titan was all one great methane ocean, but near-infrared observations by the Hubble telescope in 1994 showed dark and light patches, indicating a mix, but not revealing what was producing the differences: Continents? Oceans? Craters? One prominent surface feature in the Hubble images is a bright area about the size of Australia. Huygen's landing site is on the Titan equator west of the feature, in a dark area.

So if it survives its descent through the atmosphere, what might the little probe see? "Almost certainly craters," says Jonathan I. Lunine, a Huygens scientist with the University of Arizona. "Maybe interesting and exotic landforms and erosional features." Other scientists have suggested mountains covered in methane snow.

Lebreton says he would rather Huygens come down in a methane lake. Amid all the wizardry of sending robots to Saturn, his reason is comically simple. If the capsule hits solid ground, the impact might topple it, pointing its antenna away from Cassini and sending its transmissions into empty space. If it lands on liquid, Lebreton says, Huygens should float for five to 10 minutes, and for at least three of those precious minutes, its batteries will continue to power transmissions. In the ideal scenario—Huygens on land and upright after a fast descent—the transmission window could be as long as two hours before the mothership and its receivers disappear beneath Titan's horizon. But Lebreton, who started working on what would become Huy-



HUBBLE SPACE TELESCOPE SCIENCE INSTITUTE

In a Hubble Space Telescope map of Titan, made in 1994 during one full rotation of the moon, bright (yellow) and dark (red) areas indicate surface variations.

gens in 1984, would rather take his three minutes guaranteed.

As he approaches the spectacular climax of his career, Lebreton worries about more than Huygens tipping over. ESA is still coming to grips with the failure of another planetary lander, Beagle II, which last Christmas disappeared inexplicably during its descent to Mars. European cosmocrats are at pains now to distinguish Huygens from Beagle. The Mars craft was a shoestring adventure, they say, built for $80 million. It was built with partial funding from private U.K. companies, and its operational headquarters was at England's Open University in Milton Keynes, north of London. Huygens, adequately funded at $400 million, was incubated and bred at ESA's own scientific center, a sprawling campus-like complex tucked behind the North Sea dunes at Noordwijk, in the Netherlands.

Huygens ran into a serious problem all its own in February 2000, when a semi-annual systems checkup revealed that its communications with Cassini were garbled. Diagnosing the fault was relatively simple: The receiver that ESA had installed on the mothership had not been designed to cope with the extreme Doppler shift in radio frequencies that would occur after the probe separates from and transmits its data back to Cassini. Fixing it, on a spacecraft cruising around the solar system, was anything but simple.

With Cassini-Huygens well beyond repairman range, the only solution left was to attempt to reduce the Doppler shift so that the transmitted signals would fall within the receiver's designed bandwidth. That required ESA and NASA's Jet Propulsion Laboratory in southern California to remap

ESA

Ejection-seat specialist Martin-Baker made Huygen's parachute system and tested it in 1995, using a balloon to lift it into the atmosphere.

much of the Saturn mission, so that Cassini would be moving past Titan on the right track to receive the data transmitted from Huygens.

The long-distance adjustments took three years, as the two mission controls modeled possible trajectories, then programmers furiously wrote software instructing the spacecraft in their new routines. Huygens will now disengage from Cassini on the mothership's third pass by Titan after entering orbit around Saturn. That will happen this December 25, about six weeks later than originally planned. At the time of separation, both craft will be on a course to collide with the moon. The lander will coast another 2.5 million miles to do just that, but five days after the separation, Cassini will fire maneuvering thrusters—"slam on the brakes," as deputy program manager Earl Maize puts it—to change course and orient itself so that when Huygens starts transmitting, Cassini's high-gain antenna will be pointed toward Titan. The success of the Huygens mission depends on this maneuver.

In the meantime, Huygens will sleep until an onboard timer, set at separation, wakes up the craft's batteries and computers as Huygens approaches Ti-

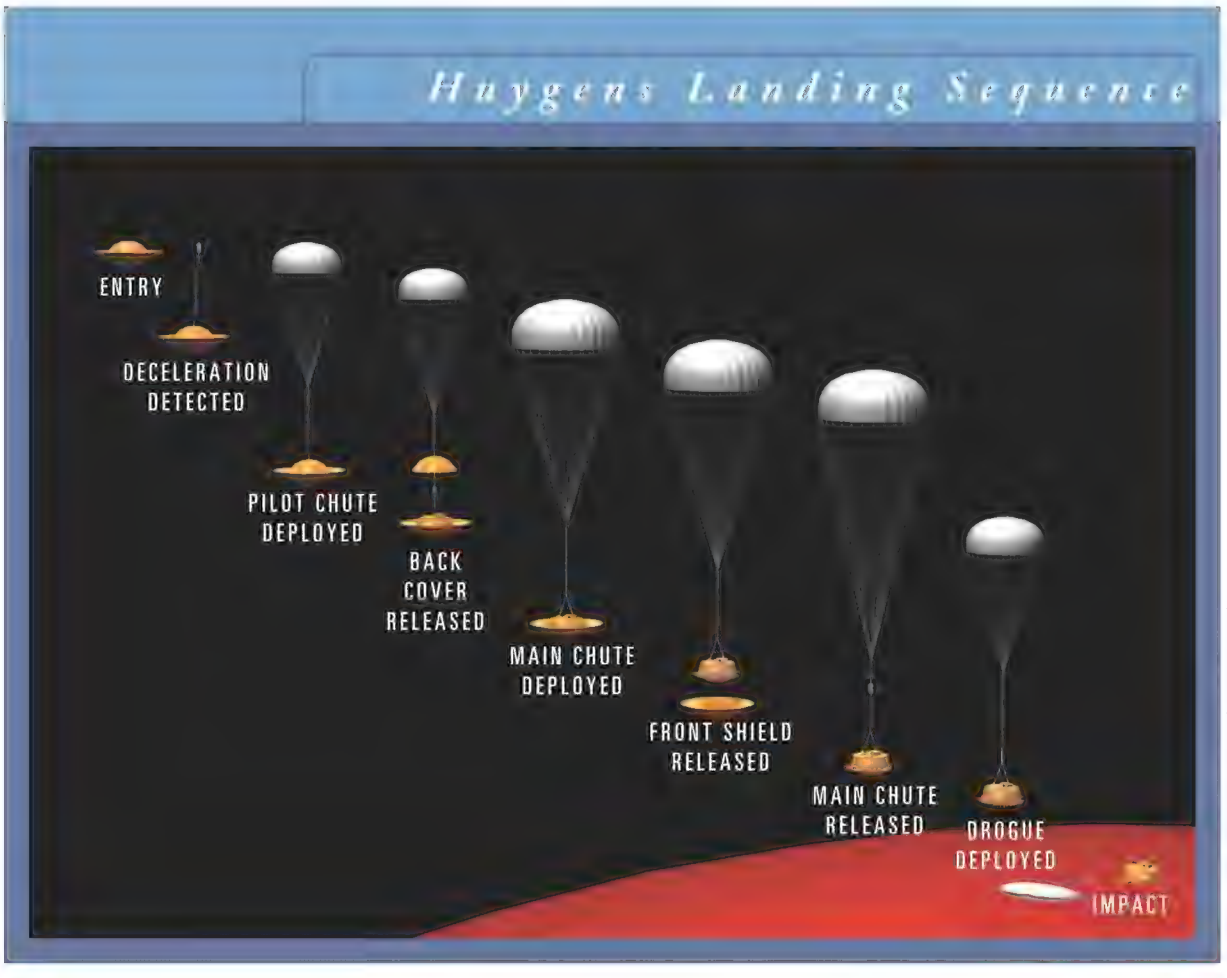
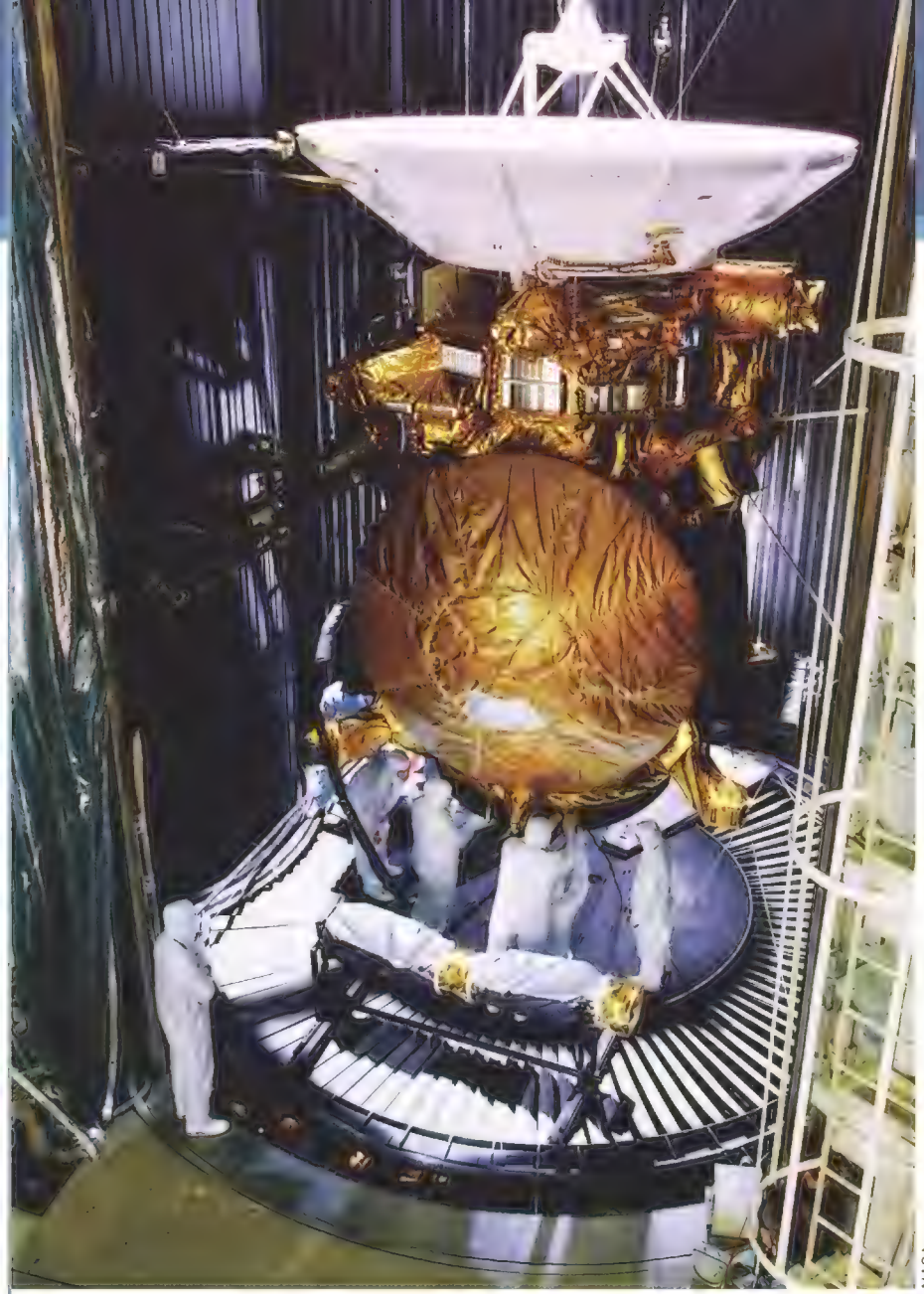


ILLUSTRATION: JOHN MACNEILL (SOURCE: ESA)



NASA

A gold Mylar cone (center) attached to Cassini will protect Huygens as it plunges Titanward.

tan's atmosphere. The batteries have enough power for the two-and-a-half-hour trip to the surface—plus an adequate reserve, in case the fall doesn't pulverize the probe.

Huygens folk say they were compensated for the labor and stress of redesigning the mission by the Americans' helpful attitude. "NASA's cooperation has been magnificent," says David Salt at Darmstadt. "JPL altered its whole four-year tour of Saturn to accommodate us. At this level it's not just a design problem. It's a political compromise too."

To core Cassini-Huygens scientists, the partnership between Darmstadt and Pasadena is nearly as thrilling as the lander's experience on Titan's surface will be—and, they fear, as ephemeral. "We thought we would open a new era of international planetary enterprise," says Toby Owen, a University of Hawaii astronomer who in 1980, with French colleague Daniel Gautier, championed what would eventually become Cassini-Huygens. "But it didn't happen, and it's a little sad that it didn't. Now America and Europe are each planning their own missions to Mercury. Why do we need two?"

Though necessary for ambitious space missions like Cassini-Huygens, international collaborations are now jeopardized by the U.S. security climate—in particular, stepped-up enforcement of the International Technology and Arms Restrictions, or ITAR, regulations. Even as the Internet makes sharing research much simpler technically, planetary scientists fear that paranoia will squelch future global space coordination. "The fact that I had to take my clothes off and be searched on a U.S. domestic flight because of my British accent creates an unpleasant impression," says David Southwood, the Imperial College of London physicist who is ESA's chief scientist. "But when we're securing a box of electronics for NASA on board the International Space Station without being allowed to know what's in it, that really makes the working climate difficult."

ESA depends on NASA's cooperation for its broader ambitions. European planetary craft would be helpless, for instance, without the U.S. Deep Space Network of communication radar antennas. But the ITAR regulations are discouraging. "Cooperation with NASA is more and more difficult," says Jean-Pierre Lebreton. "They don't want Europe working on any subsystems which they see as on a critical path."

The Planetary Society's Louis Friedman believes that Cassini-Huygens could probably not have been done without international cooperation, and he worries about the new U.S. policy of going it alone. "The recently announced lunar mission and Mars sample return are all being planned domestically without international involvement," he says, "which I think is a huge mistake."

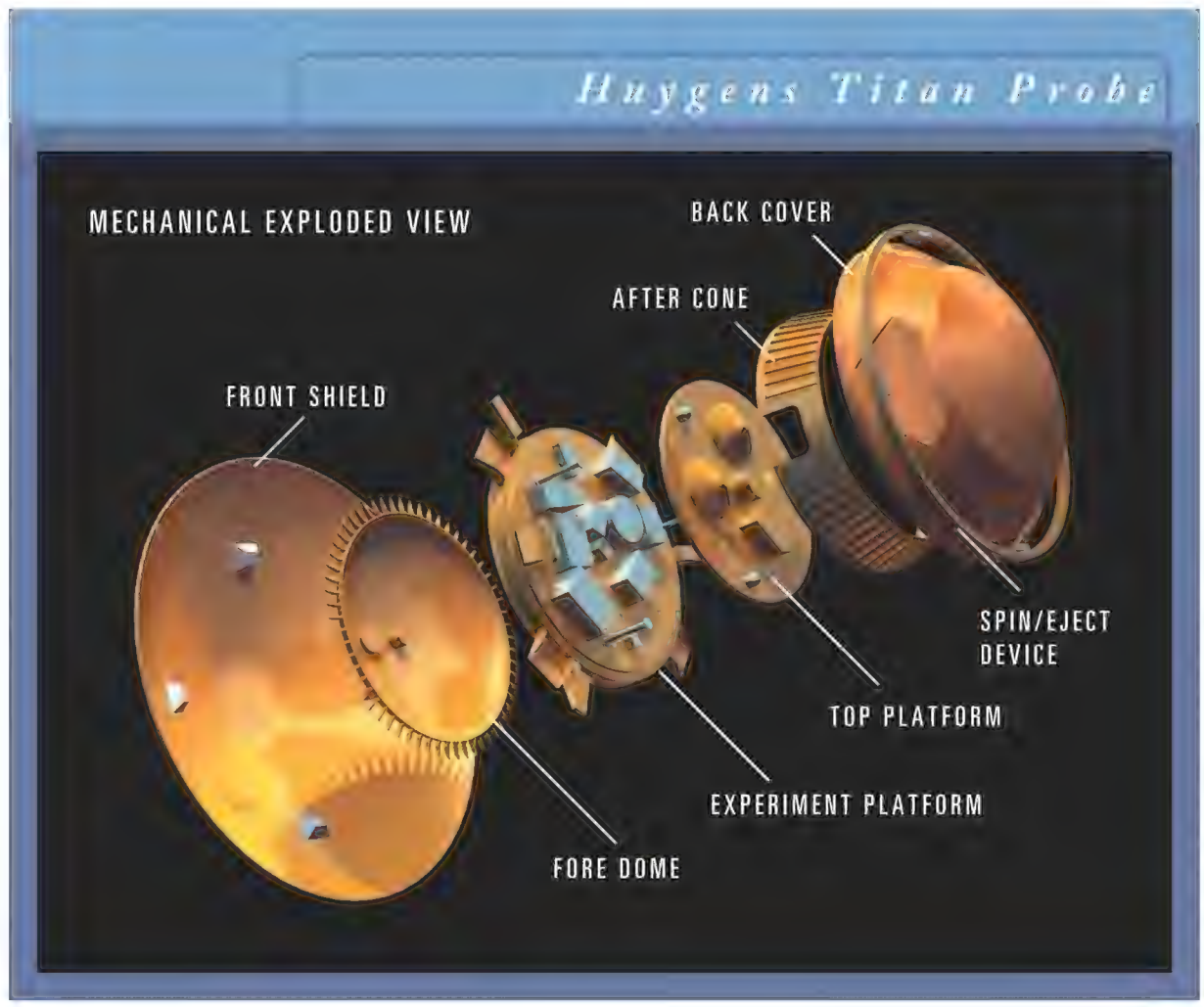


ILLUSTRATION JOHN MACNEILL (SOURCE: AEROSPATIALE)

ESA

Computer screens in Darmstadt, Germany will get the first views from Huygens of Titan's surface.

Space exploration has always been an odd blend of millennial vision and civil-service bureaucracy, and Cassini-Huygens has seen extremes of both during its quarter-century gestation. The visionaries who got it started were inspired, in their various countries, by Voyager, which opened the outer solar system in the early 1980s and convinced space aficionados that unmanned missions could be as much of a rush as Apollo. "I remember investigators fighting for a seat at the terminals at JPL so they could look at Voyager images on closed circuit," recalls the University of Arizona's Jonathan Lunine. Titan, obviously reachable yet still unseen, struck this throng of scientific imaginations as a natural focus followup.

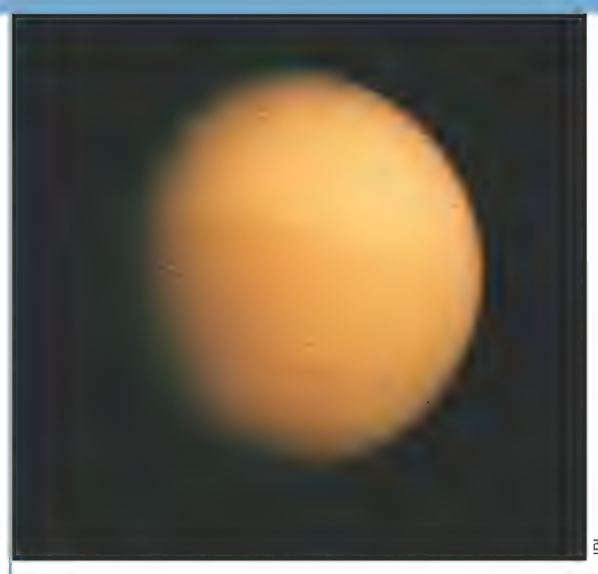
The idea of Europe going to Saturn, David Southwood recalls, was at the time "seen as laughable" to anyone outside the visionary circle and many within. ESA had been formed only seven years before—in 1973, when John Glenn was already a U.S. senator and Yuri Gagarin was long dead—and its mission, beyond building a rocket with a French name, was unclear. Then Daniel Gautier found a resourceful ally in Wing Ip, an astronomer who lobbied for a Titan probe while at Germany's Max Planck Institute in the early 1980s and now works at Taiwan's National Central University. When in 1982 ESA put out an all-points-bulletin for mission proposals, Ip set to work on a Titan plan. "ESA was very flexible just then," Ip notes. "It was a chance that didn't happen often and might not happen again."

Not that Ip—who was born in Macau, earned his doctorate at the University of California at San Diego, and then followed his thesis adviser to Max Planck—immediately found common language with Gautier, a Parisian who in the Voyager period was working at NASA's Goddard center. "Daniel, being French, thought he owned Titan and no one should interfere with his plans," Ip remembers. "But eventually he agreed to talk to me."

Upstart ESA was raising the level of its game elsewhere too. In 1985, it showed up NASA by sending the Giotto probe to Halley's Comet, cooperating with the Soviets and Japanese, who also sent spacecraft. The United States alone sat out the mission to Halley.

Besides the independent streak in U.S. space policy, NASA's bureaucratic customs differ from those of ESA, most markedly in budgetary practices. The 15 nations that kick in funds to Europe's space agency make up their collective mind slowly. The Huygens team worked for five years before its first presentation to the ESA board, and final project approval came only in 1988. But once a project is okayed, funding is locked in until the mission is finished, and that rigidity proved a lifesaver for Cassini-Huygens during decades of shifts in the U.S. Congress' moods. ESA's firm resolution stayed Congress' hand in 1993-'94, when budget hawks had Cassini in their sights, Toby Owen recalls. "When we were hanging by a thread, the director general of ESA wrote to Newt Gingrich telling him Europe wouldn't support the International Space Station if the U.S. didn't back Cassini," Owen relates. "Without ESA, we wouldn't be here."

"Here," for the little disk of hope and dreams called Huygens, is two billion miles away and approaching Saturn, its computers to be awakened for one final diagnostic before Christmas, when it cuts its Cassini umbilical cord and hurtles into black space. For space veterans like Toby Owen and Daniel Gautier, "here" tends to be a restless orbit around the globe, anywhere there are ideas to be shared and plans to be laid



JPL

Titan looks orange for the same reason skies over Los Angeles do: hydrocarbons in the atmosphere.

for the next grand scheme—a lander for Jovian moons Europa and Ganymede, a Titan orbiter accompanied by balloons that could float and photograph just above the surface. Requests for interviews for this story found Huygens scientists perpetually somewhere else—the Arizonans in Grenoble or London, the Parisians at Goddard and JPL.

For Lebreton and the cadre of scientists who have coddled Cassini-Huygens through the years, "here" means approaching one of the watersheds of their lives, and some disquiet can be expected. François Raulin, a University of Paris professor who is Huygens' senior chemist, speaks for the group when he is asked what happens if the mission flops. "I don't want to think about that," he answers flatly. What they can do from here on to avoid spectacular (if noble) failure or assure spectacular success is exactly nothing.

Charting the trajectory of a pathbreaking space mission like Cassini-Huygens reveals a vivid paradox: Those who push the edges of mankind's envelope must live by old-fashioned—certainly pre-Baby Boomer—principles of patience and dedication, soldiering on for decades in the face of technical and political obstacles, and living always with the significant chance that it won't work—that all you will have for the best years of your life is a good, honorable try. Offsetting this insecurity, space scientists live with an old-fashioned faith: that they are part of a great venture whose ultimate success is inevitable, whether now or a generation hence.

Origin of the Species | Bell XV-3 Tilt-Rotor

Nearly a half-century ago, a hybrid aircraft with a stubby nose, truncated wings, and propeller rotors became the aeronautical headliner at the Bell Helicopter Company. Work on a combination helicopter and fixed-wing aircraft had begun in the late 1940s, when the industry accepted that the helicopter's usefulness was limited by its comparatively low speed. The XV-3 was unveiled at Bell's Hurst, Texas facility on February 10, 1955, and six months later, on August 11, it was flown in hover mode for the first time by Bell's chief test pilot, Floyd Carlson. On December 18, 1958, in the hands of test pilot Bill Quinlan, it became the first tilt-rotor aircraft to transition from vertical to horizontal flight and back again. Over the next eight years the tilt-rotor underwent extensive flight testing, the last segments in May 1966 at the 40- by 80-foot full-scale wind tunnel at NASA's Ames Research Center in California. The XV-3 logged 270 flights and tutored 11 Army, Air Force, NASA, and Bell pilots. (The first XV-3 was lost in October 1956 when a rotor instability problem led to an uncontrollable descent and hard landing. A second prototype, significantly modified, stepped in to replace it.)

Initially, Bell designated the convertible aircraft the model 200. As a joint Army and Air Force project, its given name—its military designation—was XH-33 (experimental helicopter), which eventually became XV-3 (experimental vertical) to better denote its capabilities. Like a helicopter, its lift came from rotor blades, but unlike most helicopters, it had two sets of rotors, one at each wingtip. The masts supporting the rotors were rotated by electric motors from vertical to horizontal to transition the craft from helicopter mode to fixed-wing-airplane mode.

Retired Bell engineer Ken Wernicke was a key player in the company's post-XV-3 tilt-rotor development. "In 1964, I went to work for Bob Lichten, and we looked at all sorts of ways to combine the helicopter and the fixed-wing aircraft," he recalls. "We looked at slowed rotors, stopped rotors, and folding rotors. To my mind, they were all garbage. We also looked at the variable-diameter rotor, which turned out to be too complex." Basing his assessment on his experience with the XV-3 in its final years of flight testing, Wernicke says, "The tilt-rotor was the only feasible way to go." Bell Helicopter Textron experimented with the twin-engine proof-of-concept XV-15 tilt-rotor in the 1970s, and in the 1980s teamed with Boeing to produce the V-22 Osprey. Today, the direct descendant of the XV-3 is in test and evaluation at U.S. Navy and Marine Corps bases in Maryland, North Carolina, and California.

After the wind tunnel tests, XV-3 no. 2 was turned over to the U.S. Air Force Museum at Wright-Patterson Air Force Base in Ohio, then was placed in outdoor storage at Davis-Monthan Air Force Base in Arizona. Several years later it was moved to the Army Aviation Museum at Fort Rucker, Alabama, cosmetically restored, and sent back outside for display, where it slowly deteriorated.

Last fall, a photo of the XV-3 in the Hurst office of Bell Helicopter's new

BELL HELICOPTER TEXTRON VIA JAY MILLER COLLECTION

JAY MILLER

The first of two Bell XV-3s rolled out of the Hurst, Texas plant in 1955 (left). An electric motor moved the rotors from vertical to horizontal in 20 seconds (above).

r a t i o n

chief executive officer, Mike Redenbaugh, triggered a discussion. Retired Bell executive Dick Spivey noted the XV-3's importance to the company's unique tilt-rotor history, and lamented that "the aircraft is deteriorating and it's only a matter of time before restoration efforts could prove futile." Bell employees were aware of the aircraft's condition, he told Redenbaugh, "but earlier attempts to save it received virtually no company support at a corporate level."

JAY MILLER (2)

Controls included a helicopter collective that phased out as the XV-3 converted to airplane mode.

BELL HELICOPTER TEXTRON

An early V-22 Osprey (above) bears little resemblance to its XV-3 predecessor (left), but the lineage is direct.

In weeks, Spivey and Major General Charles Metcalf, director of the Air Force Museum, met in Fort Rucker, where it was agreed the XV-3 would be turned over to Bell for restoration. The aircraft's wings, horizontal tail surfaces, and upper vertical tail panel were unbolted and packed alongside the fuselage in a flatbed truck. At Bell's Plant 6 in Arlington, Texas, the various sub-assemblies were delicately off-loaded by forklift and moved into a hangar that was originally built to accommodate prototypes of the V-22. Bell plans a four-year refurbishment by a team of employees and retirees, then will deliver the *grande dame* of tilt-rotors to the Air Force Museum.

Originally concerned about corrosion, particularly of hard-to-replace parts, Bell has found little, and the company can buy or fabricate virtually everything necessary to reconstitute the aircraft back to near-original appearance. Areas of greatest concern, like the instrument panel, were essentially intact. Only two instruments were missing, but a check of old photos suggested they had never been installed.

The XV-3's mid-fuselage-mounted, 450-horsepower Pratt & Whitney R-985 radial engine had been sufficiently preserved—the spark plugs had been replaced with desiccant-filled inserts to prevent moisture from accumulating in the cylinders. But the multi-piece canopy was declared unrestorable. The restoration team plans to hand-craft replacements for the broken or cracked panels.

The restoration efforts will be shepherded by Charles Davis, one of the original XV-3 engineers. "Looking at it today, I realize just how basic it really was," he says. "But the XV-3 was able to do what it was designed for: Prove tilt-rotors could work. The V-22 and [civilian] model 609 are the result."

—Jay Miller

First Church of COMBU

BY GEORGE C. LARSON

STION

WE BELIEVE IN RUNNING ENGINES LEAN OF PEAK.

PHOTOGRAPHS BY PAUL HELLSTERN

IT HAPPENS every two months. At about noon on Friday people begin to arrive at the little airport that serves Ada, Oklahoma, population 16,000, lying roughly 80 miles southeast of Oklahoma City. Alternately griddle-flat prairie and gently rolling hills, Ada probably has a little picture of a longhorn cow and an oil well next to its name on those schoolbook maps. But the people flying in here today don't deal in cattle or petroleum.

They come from across the nation, many of them flying their own aircraft. Beech Bonanzas and Barons are the most numerous types out on the parking ramp. But here's a single-engine Cessna on stork-tall amphibious floats, its registration and little red maple leaf indicating that it flew here all the way from Canada. These visitors share one thing: They're pilots who fly aircraft powered by reciprocating engines. General aviation aircraft. The little guys.

Some of them are here because they've heard that they've been running their engines wrong all these years and they want to learn how to do it right. Some have thousands of hours, and others are barely starting out. Some are openly skeptical, and some may even harbor a private urge to unmask all that is shown and said here as fraud and sham so they can depart vindicated. Some of these people will have a hard time accepting what they will hear because it is hard to admit you've been doing something the wrong way for a very long time, especially if you are a pilot.

They have come to a class with the vaguely worded title "Advanced Pilot Seminars." The session opens on Friday evening and ends on Sunday afternoon, and the lessons are delivered in intense doses. But compared to how airmen and -women have been trained in the past, what goes on here is really closer to the founding of a religion. Call it the First Church of Combustion.

George Braly (opposite and above, right) and disciples Walter Atkinson (kneeling) and John Deakin preach the good news of engine management.

Its bishop is George Braly (pronounced BRAW-ly), an aeronautical engineer and attorney with a Wilford Brimley mustache and a booming voice cultivated in the courtroom. John Deakin and Walter Atkinson have signed on as disciples since being converted in the mid-1990s, when they were the first, aside from Braly himself, to test the tenets of the new gospel in their own airplanes. Deakin has the wise look of a wood owl. He retired in 2001 as a captain with Japan Air Lines, and the Boeing 747 time in his logbook adds up to more than four years. Atkinson's day job is dentistry, but he is also rated as an airline transport pilot, airframe-and-powerplant mechanic, and flight instructor. In the right light, he's a pretty good double for actor Fred Willard.

Braly and the two disciples promise the converted a life of airplane engine happiness, with cooler operating temperatures, fuel savings on the order of three gallons per hour for a typical six-cylinder engine in a Beech Bonanza, and reduced life-sapping carbon deposits on the valves and pistons. All they ask is that the believers ante up for precision engine monitoring systems.

The three pilots became friends while they were exploring the same subject they are about to preach in the classroom, which has filled with 36 students, each leafing silently through a fat three-ring binder. On the binders' covers is the name

of the course: "Engine Management Made Easy." The $995 tuition covers all meals (except one on Saturday night), which are taken on site to cut down on travel time to restaurants. And the students will find that they need every minute of classroom time they can get. Here is some of what they'll learn:

All reciprocating engines that burn gasoline are ruled by the incontrovertible laws of chemistry and physics. They produce power by drawing air into a cylinder, mixing it with a combustible amount of gasoline, sealing the cylinder, compressing the mixture, and igniting it at just the right moment with an electric spark. Most modern engines use some method of fuel injection to mix the gas and air. What's different about aircraft engines is that they operate at widely varying altitudes: As the airplane climbs, the air becomes thinner. With less air to support combustion, the amount of gasoline to be mixed with the oxygen molecules must be reduced accordingly. Which is why airplanes have an engine control you'll never find in a car: the mixture control. Whether it's a knob or a lever, the mixture control adjusts the flow of fuel to all the engine's cylinders.

No one asked why these four- and six-cylinder air-cooled engines ran rough when leaned. Here be dragons, said the conventional wisdom; just don't go there.

Student pilots who train in general aviation aircraft have traditionally been taught that at some altitude during the initial climb (typically 3,000 to 5,000 feet), they should move the mixture control from full rich, the setting for takeoff, to lean, then even farther to lean after they pull back the throttle to the cruise-power setting. While leaning at cruise, they learned to keep a sharp eye on an instrument that displays the temperature of the engine exhaust gas. The instrument, the exhaust gas temperature (EGT) gauge, sometimes uses a graphical bar display. (Older gauges used a needle on a dial.)

When the gasoline-air ratio is such that combustion has used up both fuel and oxygen, combustion occurs at the highest possible, or peak, temperature. (This mixture is described by chemists as "stoichiometric.") If the mixture is rich, containing an excess of fuel, or lean, containing an excess of air, the temperature of the combustion process drops. In managing mixture control, it is not a matter of what the absolute temperature of combustion is but where the mixture is relative to peak temperature, which serves only as an easily measurable reference point. Aircraft engines are not operated at peak EGT despite the apparent chemical perfection of combustion there. Cooler operating temperatures are desirable; on that all agree.

"Lean the engine until the EGT needle reaches its maximum temperature," instructors intoned, as student pilots gently pulled knobs or moved levers, "and then move it back until you are running 50 degrees on the rich side of peak temperature." The occasional inquisitive pup might ask why this is done. Instructors would warn of toasted valves, burned spark plug electrodes, holed pistons, and engine failure.

And all pilots learned through experimentation and experience that the Continental and Lycoming engines on their airplanes began to run rough around the point of peak EGT. They ran especially rough if one continued to lean the mixture past peak temperature—the dreaded lean side of peak. Roughness suggests engine failure; passengers get wide-eyed and pilots feel their palms getting moist. No one asked why these four- and six-cylinder air-cooled engines ran rough when leaned. Here be dragons, said the conventional wisdom; just don't go there. But George Braly, who bought a Beech Bonanza in 1991 and shortly thereafter installed an instrument to measure the EGT for each cylinder, noticed that when he pulled the knob that leans the mixture and reduces the fuel flow, the six cylinders of his Continental IO-520 engine reached their peak temperatures at widely scattered points across that range of motion. *Why didn't they all peak together*? he wondered.

At each seminar, 36 students absorb the elements of the new way to manage power, then disperse to carry the message nationwide.

Seminars and modification service share a hangar. Most students fly their own airplanes, and some have mods done while they learn.

On Compuserve's online aviation forum, pilots of all stripes—and those with none—could debate freely and anonymously the precepts of their training. In 1991 Braly began wondering about engine mixture management in messages to John Deakin. In an e-mail, Deakin recounts that time: "It took Compuserve's AVSIG [AViation Special Interest Group] to bring us all together and serve as a catalyst." Braly led the way, Deakin recalls, "with the rest of us asking questions he could not, at first, answer. Drove him nuts, so he began (in about 1994) the long, long trail that leads to today."

Braly says that the prevailing opinion of the time was that the peak EGT spread he saw on his engine was attributable to the design of Continental's induction system—that there was something wrong with the airflow (it's actually quite good). But mechanics adjusted the fuel injection systems on these engines on the theory that the airflow to each cylinder was equal and perfect. Using four or six containers (often cola bottles, resulting in the coinage "Coke bottle test") to catch the gas and determine the volume delivered, they would carefully tweak the system until it was metering precisely the same amount of gasoline through each injector to its respective cylinder.

Continental engines use continuous-flow fuel injection systems: The injector spritzes fuel in a flow as steady as a garden hose, even when the intake valve to the cylinder has closed. Braly began to suspect that some of the fuel that accumulated when the valve was closed was making its way down the induction system to the adjacent cylinders. If he was right, some cylinders were getting the wrong amounts of fuel, and the variation would prevent all six cylinders from arriving at peak EGT simultaneously. And if the fuel flows that brought the cylinders to peak EGT were different enough, the power outputs from all the cylinders would differ at leaner mixtures, where the power falls off quickly. No wonder the engines ran rough.

Maybe fuel distribution to each cylinder *shouldn't* be equal. Maybe it should be different.

By 1993, Braly had teamed up with an Ada-based parts manufacturer, Tim Roehl, to form General Aviation Modifications, Inc. He and Roehl began to experiment with injector nozzles calibrated to deliver fuel at a rate precisely matched to the needs of each cylinder. They had help from new microprocessor-based systems that displayed in monkey-simple graphics all the important engine data: exhaust gas temperature—not just for the engine, but for each cylinder—cylinder head temperatures, and, for turbocharged engines, turbine inlet temperature.

Braly started looking for an expert to help with the process of getting a Supplementary Type Certificate from the FAA for GAMI's new injector. Someone recommended a Texan named Carl Goulet. "I had no idea at that time that he was the former head of engineering at Teledyne Continental Motors," Braly recounts. "We had a very short and very remarkable conversation. I was considerably his junior, and he said, 'Now young man, tell me what you plan to do.' I told him, and these were his exact words: 'Hot damn! Somebody's finally gonna fix this problem!' "

GAMI applied for an STC in 1996, and the FAA approved it in the same year. At Goulet's suggestion, Braly submitted a proposal to Teledyne Continental Motors offering to supply fuel injectors and provide customer support. Hearing nothing, GAMI began to market the modification to pilots. Deakin and Atkinson were among the first to install the new injectors in their engines.

Atkinson remembers that after getting the injectors installed and heading home in his airplane, he leaned the mixture by ear, the way he'd been used to. Ignoring the EGT gauge, he liked to pull the leanerator until the engine ran rough, telling him he was just lean of peak, then adjust the mixture from there. "Except this time it wouldn't run rough," he recalls. "I kept pulling it back and it just kept running smoothly."

George Braly had been reading Internet postings by veteran airline pilots from the propeller days saying that they used to run their big radial piston engines on the lean side of peak EGT. Deakin had loads of Pratt & Whitney R-2800 time and could affirm to Braly that the names of instruments and methods may have differed, but leaning was leaning, and airline crews had been ordered by their companies to run their engines lean in order to reduce fuel consumption. But in the bargain they got cleaner spark plugs, valves, and cylinders, and perhaps the most important bonus of all—cooler operating temperatures—all as pure gravy. Braly couldn't understand why what worked in one piston engine wouldn't work in any piston engine. Born with enough tenacity for two people, he kept talking, asking questions, and reading.

That fall, a veteran pilot on the AVSIG forum told Braly that he had an old American Airlines book on how to operate the Wright R-3350. You might find it interesting, said the old vet. Perhaps the most complex powerplant ever to propel an airliner, the mighty -3350 squeezed every ounce of energy from the combustion process, in one version even using the exiting exhaust gas, already stripped of most of its energy by the turbo-supercharger, to turn a set of turbines that were geared back to the propeller shaft in order to capture the last twistlet of torque.

As soon as Braly got the old operating manual and read about the American pilots' lean-of-peak technique, he grabbed the factory graphs and charts for his Continental engine and calcu-

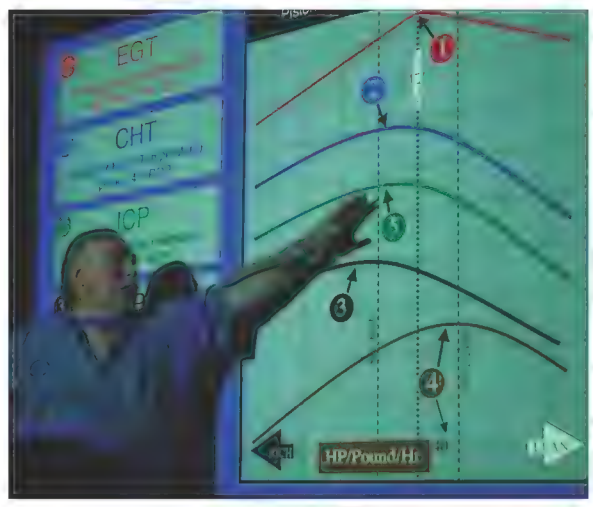
The point corresponded to a power and fuel flow setting at exactly 50° F. lean of peak EGT. It was the eureka moment.

lated where his engine would be on the power curve if it were running under the same settings the -3350s were run at. The point corresponded to a power and fuel flow setting at exactly 50 degrees Fahrenheit lean of peak EGT. "It was the eureka moment," he recalls. By the summer of 1997, Braly, Deakin, and Atkinson were routinely flying with their engines running on the lean side of peak EGT and were ready to tell the world.

For a couple of years they hosted flying clubs at GAMI's hangar at Ada on Saturday mornings. In 2001, Atkinson put together a slide show to make the whole thing clearer.

Braly still wasn't satisfied with the data he was getting from the sensors and instruments. In 1998 Goulet had urged him to probe deeper, telling him that he needed to develop the means for measuring real-time cylinder pressure events. Goulet said he himself had spent a lot of time looking at combustion pressure data and that Braly would never really understand the engines until he understood the combustion events. "Within 60 days after that, I was flying with the first prototype combustion pressure sensors," Braly says. Now he could record the rise in pressure within the cylinder as the mixture began to ignite. On the first flight, Braly compared lean and rich combustion events at the same horsepower and found that the lean event produced significantly lower cylinder pressures and lower cylinder head temperatures. It was the second eureka moment.

Braly began to imagine a facility where he could study engines all day every day without having to go flying. He wanted to be able to change conditions like ignition timing, fuel octane, intra-cylinder pressure, and air inlet temperature—in short, to build a laboratory around an off-the-shelf, six-cylinder aircraft engine that he could poke and prod and see what happened. In 1999, GAMI built just such a lab around a six-cylinder Lycoming TIO-540. "We probably know more about the



After two and a half days in Ada, every student can explain the why's and how's of the fuel mixture graph.

Lycoming TIO-540 than any other engine, and we probably know more about it than anyone else in the world," Braly says. Later that year, when Carl Goulet died, the lab was named for him.

With the lab up and running, Braly could gather data and translate it into operating knowledge any pilot could use. He expresses it in a graph showing the impact on an engine of the fuel mixture (opposite); this set of curves forms the new orthodoxy of engine operation. The horizontal axis can be thought of as the movement of the mixture control from full rich on the left to lean on the right. The topmost curve indicates that EGT peaks at a certain value and forms the reference point (dotted line) for managing the engine's operation. The second curve plots cylinder head temperature across the range of fuel flow, showing that a pilot can expect CHT to max out at a point slightly to the rich side of peak EGT. Almost perfectly parallel to CHT is the internal cylinder pressure curve. Just beneath it, the horsepower plot reveals that maximum power is reached in an even richer area of the fuel flow range. A curve of computed points, at the very bottom of the group, plots horsepower per pound of fuel burned per hour—a way of expressing fuel efficiency.

Braly's work showed—and the seminar teaches—that once the fuel injection systems of Lycoming and Continental engines have been adjusted to deliver the proper quantities of fuel to each cylinder, pilots can operate their engines over on the right side of that set of curves. (And way over on the left too, with rich mixtures at high power. It's the range in the middle students will learn to avoid.) Pilots in the classroom learn that cylinder head temperature—a critical measure of engine health—rises because of rising intra-cylinder pressure. Operate on the right side of the curve with a lean mixture and CHT drops off nicely.

But over on the right side of the curves, the horsepower falls off too. How did the airlines recover the power lost when they ordered their crews to lean the mixture? The old books and the veteran pilots revealed the simple answer: They moved the throttle back up from its reduced cruise-power setting until they got the horsepower back to no more than about 65 percent of rated power. And when they did that, they found themselves with an engine that was operating at the peak of the last curve—max fuel efficiency. In effect the First Church of Combustion is preaching the gospel of using both fuel and air, rather than just fuel, to manage engine power.

(For a more detailed explanation of the Wright Aeronautical Division—WAD—Leaning Procedure, read Braly's narrative at *www.gami.com*; click on "Future Series." Turbocharged engines offer a more complex picture.)

In June 2002 about 35 pilots from the Dallas chapter of the Experimental Aircraft Association flew to Ada to hear about the new way to operate their engines. They departed converted, and that visit led to the first formal seminar in Ada in September 2002 for paying customers.

It's hard to overcome the orthodoxy of the operating manuals and the notion that if engines were meant to be run this way, the aircraft and engine manufacturers would revise the manual. Four years ago, Textron Lycoming issued an advisory to its customers explaining the company's operating recommendations. "Operating an engine 'on the edge' is possible," the advisory states, "provided the pilot is extremely precise, has good instrumen-

tation, and monitors the engine condition full time. For 98% of the pilots, it is an invitation to potential trouble."

Some people depart the weekend in Ada unmoved and cling to the old ways. But to date, Braly and his disciples have converted several hundred pilots, who return to their homes merrily pulling the mixture controls on their engines with abandon. Pull the mixture, all ye souls! Fly lean of peak and be free! Until you have done it yourself, some of them say, you have not tasted of the fruit.

Fred Scott, a farmer and Beech Baron owner from southern Virginia, recalls his first experience: "A friend and I had climbed to 11,000 feet on the way back home from the school. And we pulled it back through the peak [EGT]. 'Engine's gonna melt,' they used to tell us. We're thinking, *Well, we gotta believe.* And sure enough, the head temperatures went down and it was like a book opening, a complete revelation to see the science you learned in the school made sense. All of a sudden it was all true. We were like two little kids."

Students at the seminar are surprised when they don't hear the bad-mouthing of Continental or Lycoming engines that's common among pilots—"Lyconentals," they call them, a derisive term that encapsulates the notion that both engines are old technology and essentially interchangeable. All three teachers certainly have the chops to criticize, but they're very complimentary of the durability and efficiency of both manufacturers' engines.

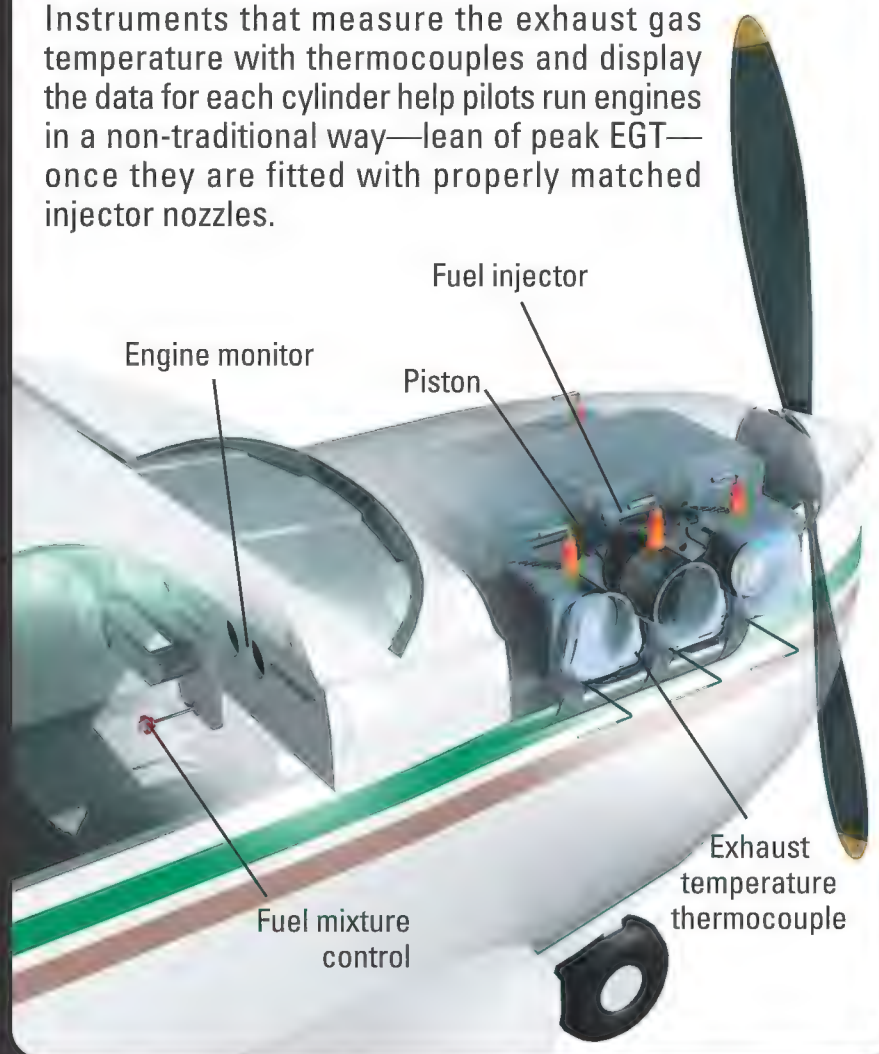
As for Braly, he and the GAMI crew are now working on an electronic spark ignition system that monitors intracylinder pressure and adjusts the spark timing automatically to manage the pressure generated by combustion and eliminate detonation ("engine knock," in car talk), a condition in which combustion occurs too early, raising intracylinder pressure and ultimately destroying the engine. Each seminar class watches as the big TIO-540, running on 100-octane low-lead aviation gasoline, is switched to rotgut unleaded auto gas without missing a beat. Braly can't give a firm date by which FAA certification will be complete. Pray it's soon.

The newest graphic digital engine instruments provide highly accurate temperature data: here, EGT and CHT.

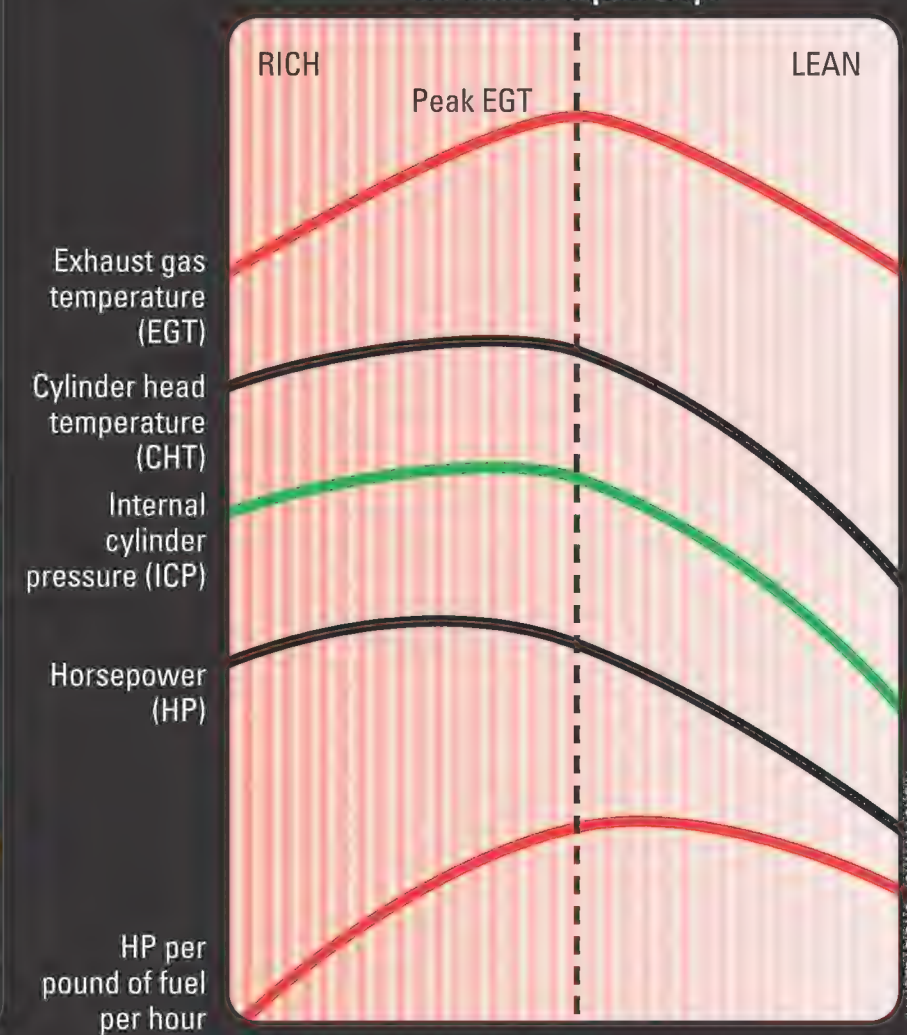
GEORGE LARSON

Keys To Engine Management

Instruments that measure the exhaust gas temperature with thermocouples and display the data for each cylinder help pilots run engines in a non-traditional way—lean of peak EGT—once they are fitted with properly matched injector nozzles.



Fuel Mixture Impact Graph



ILLUSTRATIONS: JOHN MACNEILL

ALL GUTS NO GLORY

THE BRAVE, DOOMED CREWS OF WORLD WAR II ESCORT CARRIERS.

BY JAMES L. NOLES, JR.

The pilots of squadron VC-39 flew their missions from the Liscome Bay, *a carrier painfully vulnerable to attack.*

NATIONAL ARCHIVES

LIEUTENANT JOSEPH CASTELLO DROPPED HIS FM-1 WILDCAT OUT OF THE MORNING SKY AND, WITH A WAGGLE OF HIS WINGS, LINED UP ON THE U.S. NAVY ESCORT CARRIER THE *LISCOME BAY*. ONE OF 36 PILOTS PRACTICING LANDINGS THAT OCTOBER DAY IN 1943, CASTELLO WAS PREPARING TO JOIN U.S. FORCES IN TRYING TO DISLODGE THE JAPANESE FROM STRONGHOLDS IN THE SOLOMON ISLANDS.

Perched on a platform off the stern, the landing signal officer raised his paddles and guided Castello in. Even the best landing was little more than a controlled crash on the largest fleet attack carriers, but on the much smaller deck of an escort carrier, the feat was even dicier. Everyone on the *Liscome Bay*'s flight deck and bridge tensely watched the fighter's approach.

He's coming in a bit too high, thought Jim Beasley, one of the ship's quartermasters. Beasley was no aviator, but he knew a bolter coming when he saw one.

Castello hit the flight deck fast and hard, bouncing over the arresting wires. For a moment, the Wildcat tried to keep flying. Then it smashed back down. Its left landing gear was sheared off as the aircraft skidded across the deck. With a screech of metal, the mangled fighter disappeared over the starboard side and into the Pacific Ocean.

Beasley ran to the ship's edge and saw Castello struggling in the cockpit. Before the pilot could squirm free, his Wildcat nosed over into the foaming water. Castello's death on October 16 marked the *Liscome Bay*'s first casualty. "It left an unforgettable imprint on my mind," Beasley wrote in an unpublished memoir 50 years later. "I had seen him kiss his wife and child goodbye on the dock in San Diego."

Castello's fellow Wildcat and TBF Avenger torpedo bomber pilots in Composite Squadron 39 (VC-39) were horrified. If an experienced pilot like the lieutenant could lose his life in a training accident within sight of the California coast, what chance did they stand when the shooting started? As fate would have it, not much of a chance at all. Seventy-seven pilots and crewmen of VC-39 crossed the *Liscome Bay*'s gangplank for the first time in San Diego. For over half of them, it would be a one-way trip.

The *Liscome Bay* set a grim record during the war—for the greatest loss of life in the sinking of a U.S. carrier—yet few people know about the ship. (More men died in a Japanese air attack on the *Essex*-class carrier *Franklin*, but that ship remained afloat.) I heard the *Liscome Bay*'s story only because I was doing research for a book that involved one of the survivors, but the more I looked into it, the more I was convinced that the history of the *Liscome Bay* should be told. The resulting book, *Twenty-three Minutes to Eternity*, was published last month by the University of Alabama Press. It joins a surprisingly small body of literature on the escort carriers, but I have found that these

An escort carrier's answer to submarines, the Avenger torpedo bomber helped protect shipping in the Atlantic.

ALL PHOTOGRAPHS: NAVAL INSTITUTE PHOTO ARCHIVE, EXCEPT AS NOTED

NATIONAL ARCHIVES

The second of 50 escort carriers rushed into service, the Liscome Bay *ferried aircraft from San Francisco to San Diego before joining the fight in the fall of 1943. Earlier that year, Henry Kaiser (at right) presented a model of the class to President Roosevelt.*

ships' histories, individually and collectively, provide a perspective on World War II naval history that isn't found in books on the larger attack carriers.

The escort carriers—formally "carrier vessel escorts," or CVEs—were conceived as the solution to a problem President Franklin Roosevelt faced before the United States entered the war: Ships carrying supplies to Great Britain and the Soviet Union were being sunk in the Atlantic by German U-boats. Beginning in January 1941, Roosevelt pressured a hesitant Navy to convert merchant ships and oilers into light aircraft carriers capable of escorting the vulnerable convoys. It designated the converted merchant ships the *Bogue* class, after the first escort carrier commissioned from those conversions, and labeled the covered oilers the *Cimmaron* class. By the time these converted carriers entered the fray in 1943—carrying a typical load of 27 Wildcat fighters and TBF/M Avenger torpedo bombers—the U.S. Navy had begun to engage

Avengers also provided cover for landing forces, like these, hitting a Philippine beach.

the Japanese in the southwest Pacific, and the war's tide was turning slowly in the Allies' favor.

But the increasing number of naval operations demanded more escort carriers. In 1943, industrialist Henry J. Kaiser secured a contract to build 50 carriers over the course of a year—a seemingly impossible feat. Kaiser's 500-foot-long CVEs would be just over half the length of the *Essex*-class fleet carriers and, with a top speed of 18 knots (21 mph), would be only half as fast. The Navy intended these warships, the first escort carriers designed from the keel up, to escort convoys, hunt U-boats in the Atlantic, and provide close air support for Allied invasion troops in the Pacific. But how would such small, slow ships fare when they sailed into battle?

As far as Kaiser was concerned, that was the Navy's problem. "Eighteen or more by '44," his shipyards pledged. Kaiser was already cranking out cargo-carrying Liberty ships in under 60 days each. He applied the same techniques to his escort carriers, assembling much of each ship from prefabricated sections.

The U.S. public had dubbed the escort carriers "baby flattops" and "jeep carriers"; the British called them "Woolworth carriers," after the chain of American dime stores. The cookie-cutter qualities of mass production and the hurried schedule made the sailors assigned to the ships uncomfortable. At least one old salt complained that the escort carrier designation "CVE" stood for "combustible, vulnerable, and expendable."

Kaiser launched his first escort carrier, the *Casablanca*, on April 5, 1943. The ship's name was also bestowed on the class of CVEs that followed. The second, the *Liscome Bay*, came two weeks later. And by the end of the contract, Kaiser had delivered all 50—roughly one a week. Mindful of that record, and eyeing the carriers' welded hulls, thin bulkheads, temperamental steam engines, and pell-mell construction schedules, skeptical sailors labeled them "Kaiser coffins."

THE COOKIE-CUTTER QUALITIES OF MASS PRODUCTION AND THE HURRIED SCHEDULE MADE THE SAILORS ASSIGNED TO THE SHIPS UNCOMFORTABLE. AT LEAST ONE OLD SALT COMPLAINED THAT THE ESCORT CARRIER DESIGNATION "CVE" STOOD FOR "COMBUSTIBLE, VULNERABLE, AND EXPENDABLE."

But the *Liscome Bay*'s officers and sailors had little time to dwell on possible shortcomings. A hasty shakedown cruise followed the carrier's August 7, 1943 commissioning, but the pilots and

their 28 Wildcats and Avengers did not embark until mid-October, and steamed for Pearl Harbor on the 22nd. There the crew received its first orders for combat—to provide air support for the Army's invasion of Makin Atoll, a tiny island 100 miles north of Tarawa in the Gilbert chain, which lies about halfway between Hawaii and Australia.

For four days, the *Liscome Bay*'s aircraft, joined by others from sister carriers the *Coral Sea* and the *Corregidor*, strafed and bombed Japanese positions on Makin. No enemy fighters challenged them, but, as the days passed, the *Liscome Bay*'s crew grew nervous. How long would their slow, thin-skinned carrier have to remain off Makin?

In the pre-dawn darkness of November 24, the crew's worst fears were realized. A torpedo launched from the Japanese submarine *I-175* smashed into the carrier's aft starboard quarter and exploded in the worst possible place—a magazine in which nearly 70,000 pounds of bombs were stowed. A little over a mile away, the skipper of the battleship *Mississippi* watched in shock:

"The first indication of the hit was a bright quick flash of fire," the captain wrote later, "followed within two or three seconds by a great explosion and towering mass of fire which seemed to engulf the ship and brilliantly illuminated the surrounding area. This column of fire rose to a height of several hundred feet carrying with it burning wreckage and fragments which showered down into the sea for several minutes on all sides. A second heavy explosion was seen and heard about twenty seconds after the first.... When the cloud of fire lifted from the ship she was seen to be a blazing wreck with fires raging throughout her structure."

Ensign Selden N. May, one of VC-39's Wildcat pilots, was asleep in an upper bunk when the torpedo hit. The blast knocked him onto the steel deck. "I was stunned," May recalled in a survivor's statement, "and woke up when [men] started running through my room. I slept in the raw, but I grabbed my life preserver and started running to find a way off the ship. There were continuous explosions. I finally climbed through a hole in the port antiaircraft [guns' ammunition] clip room onto the port catwalk. The ship was listing about thirty degrees to the starboard. I saw two men with a rubber raft just below me [and] I went down the rope and joined them."

All along the flight deck, on the catwalks, and through holes blown in the side of the ship, men slipped down lines or simply jumped into the dark sea to escape the spreading conflagration. Twenty-three minutes after the torpedo strike, the *Liscome Bay* sank, along with 644 men. Among those lost was Cook Third Class Doris "Dorie" Miller, the first black sailor to receive the Navy's highest award for heroism. During the Japanese attack on Pearl Harbor, Miller had been a mess attendant aboard the battleship *West Virginia*, and his actions that day—firing an anti-aircraft machine gun he had never been trained to use, plus moving his wounded captain and shipmates out of harm's way—earned him the Navy Cross.

The *Liscome Bay*'s skipper, Captain Irving D. Wiltsie, last seen scouring the ship for survivors, also went down with the ship.

The same day that the *Liscome Bay* sank in the Pacific, the *Block Island*, a *Bogue*-class escort carrier converted from a merchant ship hull, stood out of Norfolk on an assignment that demonstrated the versatility of the baby flattops. Serving as the nucleus of an anti-submarine hunter-killer group (usually consisting of a CVE and four or five destroyers and/or destroyer escorts), the *Block Island* was tasked with destroying German U-boats in the Atlantic. The pilots newly assigned to the ship, the VC-55 squadron, had claimed their first enemy sub a month earlier.

Lieutenant Denny Moller was VC-55's assistant engineering officer. Like all of the squadron's pilots, he endured a demanding schedule of both day and night flying. The *Block Island* operated within a screen of four destroyer escorts, launching patrols of four aircraft. Each airplane took a quadrant and carved it into 30-degree slices—out, across, and then back in to the carrier. Because the pilots had to observe radio silence at night, they had to find their way back to the moving carrier by relying on dead reckoning—flying a compass heading for a calculated time and hoping to spot the carrier when the time was up.

"We would try to work out our navigation beforehand," Moller explains, "so on takeoff, you always

"THE FIRST INDICATION OF THE HIT WAS A BRIGHT QUICK FLASH OF FIRE, FOLLOWED WITHIN TWO OR THREE SECONDS BY A GREAT EXPLOSION AND TOWERING MASS OF FIRE WHICH SEEMED TO ENGULF THE SHIP AND BRILLIANTLY ILLUMINATED THE SURROUNDING AREA."

The hangar deck of the USS Charger, *crammed with F4F-4 Wildcats on their way to war.*

hated to see the flight deck crew holding up a chalkboard that said, 'The course of the carrier will be so-and-so, the wind direction is so-and-so. Good luck!' That meant you had to figure out a whole new set of navigational figures on the go. That wasn't easy in a dark cockpit at night."

On March 19, 1944, VC-55 claimed another German sub, the *U-1059*. But on May 29 near the Canary Islands, the *Block Island*'s prey turned hunter. As dusk fell, the *U-549* slipped through the destroyer escort screen and launched three torpedoes into the carrier.

Moller dashed topside with a group of pilots from his squadron's ready room. The torpedo strikes had put a massive fracture in the *Block Island*'s flight deck. Standing precariously on the listing deck, Moller soon heard the inevitable order: "Abandon ship."

"I wasn't much for swan dives from that height," Moller says, "so we took off our shoes, tied them together by the laces, hung them around our necks, and slid down ropes into the water. Of course our shoes floated away immediately."

Moller and his companions inflated their Mae West life jackets and soon found a cork float net. Before the night was over, the destroyer escort *Ahrens* plucked them from the chilly Atlantic. In contrast to the *Liscome Bay*, only six men were lost. After 30 days of survivor's leave, Moller was back in action with a new hunter-killer group on board the *Croatan*.

Moller was not the only aviator seeking a shipboard home in the summer of 1944. In the Pacific, ensigns Ken Snyder and Darrell "Smoke" Bennett were looking for a carrier squadron. Finally, two slots opened up on escort carriers.

"We flipped for it," Snyder recalls. "Smoke got *Gambier Bay*, and I got *Kitkun Bay*."

Soon after, Snyder joined VC-5 in the *Kitkun Bay* as a Wildcat pilot. "Oh my gosh, they were solid little devils," Snyder says, "but a little lively on their narrow landing gear. Still, it was a good plane. It could take an awful lot of punishment, and dish it out too."

That summer in the *Kitkun Bay* was a busy one for Snyder and his comrades, flying in support of the bloody landings on Tinian, Guam, Anguar, and Peleliu as U.S. forces drew ever closer to the Philippines. With each invasion, the escort-carrier-based squadrons proved their mettle. Over Peleliu they disrupted a rare Japanese tank attack against a vulnerable U.S. Marine beachhead. Their finest hour, however, was yet to come.

October 25, 1944: As Japanese shells explode near U.S. ships (background), the Kitkun Bay *launches its fighters.*

As U.S. forces converged on the Philippines in the fall of 1944, Japan's admirals pieced together an audacious counterattack. In a complex operation, the Japanese lured the larger U.S. carriers from their posts guarding the approaches to the U.S. beachhead on Leyte. Their departure left the task force unit known as Taffy 3, which included Snyder's ship, the *Kitkun Bay*, directly in harm's way in the waters east of Samar.

On October 24, 1944, as the *Kitkun Bay*'s sailors grabbed a quick breakfast, a Japanese force of nearly two dozen battleships, cruisers, and destroyers approached, concealed in a morning mist. Only the lightly armed escort carriers, destroyers, and destroyer escorts of Taffy 3 stood between Vice Admiral Takeo

To protect Leyte beachheads, escort carriers off Samar took a pounding—but held on.

Kurita's armada and the transports gathered along the Leyte beachheads.

Ensign Hans L. Jensen, piloting a TBM Avenger from the escort carrier *Kadashan Bay*, was the first to spot the Japanese force. At 6:30 a.m., anti-aircraft fire exploded around Jensen's Avenger, giving Rear Admiral Clifton A.F. "Zippy" Sprague and his skippers the first sign of impending disaster. Moments later, Ensign William C. Brooks, a pilot from the CVE *St. Lo*, radioed: "Enemy surface force of four battleships, seven cruisers, and 11 destroyers sighted 20 miles northwest of your task group and closing in on you at 30 knots!" For the poorly armed and armored escort carriers, which barely made 18 knots, this was grim news. Sprague ordered his baby flattops to launch all airplanes.

At 6:55, flight quarters sounded in the *Kitkun Bay*, sending Snyder and his comrades sprinting to their aircraft. By the time the last one catapulted skyward, geysers spouting from Japanese shells bracketed the ship.

Snyder and his section leader, Jack Krouse, headed for the enemy ships. Elsewhere in the overcast sky, in disorganized clusters and even alone, U.S. pilots were hurling their Wildcats and Avengers against the enemy fleet.

Snyder pointed his Wildcat's stubby nose at the first Japanese ship he saw. Anti-aircraft shells burst around his aircraft and punched holes in its wings and fuselage. Still he roared on, answering its gunners with his .50-caliber machine guns. Then on to the next ship.

"We hardly had time to pick out targets," Snyder recalls. "It was just like one big daisy chain."

As the morning passed, Japanese gunfire took its toll in the running duel. Shells straddled the escort carrier *White Plains*, missing it but striking close enough to temporarily knock out the steering control. Japanese guns pummeled the CVEs *Kalinin Bay*, *Fanshaw Bay*, and *Gambier Bay*. Mortally wounded, the *Gambier Bay*—the ship that, but for a coin toss, would have been Snyder's home—rolled over and sank. Taffy 3's destroyers and destroyer escorts valiantly attacked the far larger Japanese warships and suffered grievous losses as well. The destroyers *Hoel* and *Johnston* were literally blasted out of the water, as was the destroyer escort *Samuel B. Roberts*.

Before long, Snyder, like so many other pilots engaged in the chaotic battle, ran out of ammunition. Still he harassed the Japanese, with mock gun runs, and even "bombed" an enemy ship with his empty drop tank—anything to draw the Japanese away from the practically defenseless escort carriers.

"By then, the gas gauge needle was bobbing around zero," Snyder says. "I knew that meant I had about 20 minutes of fuel left. Krouse, my section leader and wingman, was facing the same situation. He decided we should head for the airfield the Army had just captured ashore at Tacloban.

"When we got to Tacloban, it was full of wrecked airplanes. There was nowhere to land. Then we remembered another airstrip at Dulag, 15 miles to the south, and turned for it. It was a mess too, but we made it in safely."

Snyder's buddy Smoke Bennett was among the survivors of the *Gambier Bay*.

Meanwhile, the CVE pilots' swarming attacks, coupled with bold maneuvers by Sprague's destroyers and destroyer escorts, had thrown Kurita into disarray. Demoralized after losing three cruisers to the

At under 8,000 pounds fully loaded, the F4F Wildcat was a perfect match for the lightly constructed escort carriers.

outgunned Americans, he withdrew his ships. Thus ended the so-called Battle off Samar, which naval historian Samuel Eliot Morison later christened "the most remarkable of the Pacific war."

The naval actions around the Philippines that October spelled the end of the Imperial Japanese Navy as a mortal threat to the U.S. fleet. But the advent of Japan's suicidal kamikazes, which claimed the *St. Lo* the day after Taffy 3's ordeal, demanded the continued attention of the escort carriers and their pilots. So did future amphibious assaults.

On May 3, 1945, a brand-new escort carrier, again christened the *Block Island*, arrived off Okinawa. It was one of the new *Commencement Bay*-class escort carriers: larger, faster, and sturdier than Kaiser's ships. In command was Captain Francis M. Hughes, who had skippered the original *Block Island*, lost to the *U-549* a year earlier, and among the crew were many survivors of the sinking. Despite the connection to the past, the new *Block Island* represented a step toward the escort carriers' future: Rather than U.S. Navy aviators, the CVE carried the first Marine Corps carrier air group, MCVG-1, flying Avengers and F4U Corsairs and F6F Hellcat fighters. This concept was born of the Corps' longstanding desire for its own pilots to support the leathernecks battling the Japanese on such islands as Okinawa and Iwo Jima.

Major R. Bruce Porter initially served as the executive officer of the *Block Island*'s fighter squadron, VMF-511. Before the war was over, Porter would become an ace and earn acclaim as one of the Marine Corps' most accomplished night fighter pilots. But even he never took night landings on the escort carrier lightly. "I logged 43 night landings," Porter says, "but I didn't do any of them by myself. The good Lord was helping me on every one."

Marines like Porter, flying off the *Block Island* and three other CVEs, joined the Navy's aviators to provide critical air support during the battle for Okinawa. Later, in the Korean War, escort carriers such as the *Sicily*, *Rendova*, *Bairoko*, and *Badoeng Strait* supported United Nations forces. Nevertheless, the force reductions after World War II resulted in the end of the escort carriers.

In 1947 the Navy's Project 27A focused on modernizing *Essex*-class carriers to enable them to handle larger, heavier jets, capable of delivering nuclear weapons and launching guided missiles. In this future, escort carriers had no role. One by one the Navy sold them off as scrap metal. Today the Navy's fleet of small-deck *Wasp*- and *Tarawa*-class amphibious assault ships, launching Marine aviators in SuperCobra helicopter gunships and AV-88 Harrier vertical/short-takeoff-and-landing "jump jets," offers the most vivid reminder of the escort carriers' heyday in the Pacific, when scarcely an amphibious landing was made without Wildcats and Avengers launched from a CVE screaming overhead.

Photographer John Fleck, anxious for a creative project to mix with his corporate work, looked to airplanes in Indiana for inspiration. The resulting series, which he hopes to turn into a book, should express, he says, "the personalities of aircraft through portraits of people—like people looking like their pets." Clockwise from above: Anthony Rostanza, who restores Piper Cubs in Franklin, holds an award from the Federal Aviation Administration for 50 years in aviation maintenance. Rick Ropkey basks in the glow of his Antonov An-2TP, reassembled for him in Indianapolis by mechanics who had built An-2s under license in Poland. Jim Shuttleworth mimics his TF-51D Mustang in Huntington in 1997. In Fort Wayne, a mechanic lays hands on a Hawker Sea Fury. Marcus Schrenker "spent most of his time inverted in his Extra 300 when he was not at his desk working as an investment advisor," Fleck says.

JOHN GOOD

Karl Streidieck soars by a Pennsylvania ridgetop landing strip in a Duo Discus.

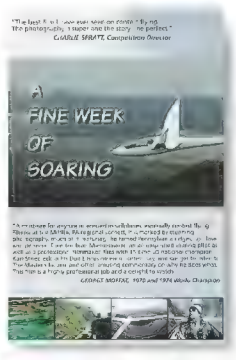
One Swell Swoop

A Fine Week of Soaring

directed by Juan Mandalbaum. Geovision, 2004. DVD, 69 min., $34.90.

Don't let the bland title fool you. *A Fine Week of Soaring* is a must-see for every power pilot who has wondered what experienced soaring pilots do when they cut loose and disappear for the day.

Filmed at Mifflin, Pennsylvania, during a regional soaring contest, the video includes beautiful aerial photography over the ridges of the Allegheny mountains. Producer-director-writer Juan Mandalbaum, an accomplished soaring pilot and professional moviemaker, shoots from the back seat of his Duo Discus sailplane with a master at the controls: 15-time U.S. national champion Karl Striedieck. Striedieck discovered in the late 1960s the advantages of flying over Appalachian ridges, where he stunned the soaring world by using a modest glider to set world distance records.



Unlike previous soaring films, this one puts you in the cockpit and keeps you there. Contrary to the common impression that soaring is a serene way to fly, the movie's portrayal of sailplane racing proves it is an intense and technically challenging sport. Perhaps no other aviation sport requires this combination of continual decision-making, precision flying, and knowledge of micro-meteorology and terrain.

Ridge soaring at sites such as Mifflin also requires extensive knowledge of the local geography to ensure safety as well as speed. George Moffat, the dean of American competition soaring, comments: "Soaring is finding your way through the invisible geography of the sky," but shots of the topography overflown and the inflight commentary illustrate how daunting the sport can be when the pilot is soaring 50 feet above the trees at 100 knots.

The wide-angle camera placed on the tail of the Duo Discus gives an excellent view of what Striedieck sees, a camera behind his shoulder allows you to see the cockpit action, and audio of the interaction between Striedieck and Mandalbaum supplies context, meanings, and instruction.

GPS recording units tailored to sailplane use are now mandatory in competition. As a result, 3D terrain mapping can be combined with each flight's track data (and that of nearby competitors). Mandalbaum uses the technology to create digital animations, which turn the film into a gripping video game and give viewers a much improved feel for what goes on during a race.

Excellent production values, storyline, editing, and an unobtrusive musical score make this video part essay, part documentary, part instruction, and all soaring enjoyment—one of the best films on soaring I have seen, and one that will appeal to pilots of all stripes.

—Tony Burton is the editor of free flight, *the Soaring Association of Canada's magazine.*

Mars on Earth

by Robert Zubrin. Tarcher/Penguin, 2003. 352 pp., $28.95.

You have to give Robert Zubrin points for enthusiasm, and for single-minded dedication. Over the past decade there's hardly been a more passionate champion of sending people to Mars. As an engineer for Martin Marietta (now Lockheed Martin), he came up with a concept called Mars Direct, which was notable as much for its impatience as for its economy. Zubrin's point was that we didn't have to wait to send people to Mars; nor did we have to bankrupt the national treasury. If we used Martian resources to make rocket fuel and supplies for the landing party, the budget NASA was estimating for a Mars mission—in the hundreds of billions of dollars—could drop dramatically.

Since then, as an author, lecturer, and creator of the grassroots Mars Society, Zubrin has stayed doggedly on message.

More Accurate than Einstein's Theory

The classic watch built with German precision to 1 billionth of a second

There is a new super-accurate government device that gives you a perfect use for atomic theory. The US government has engineered the most ingenious, most accurate clock in the world, the new F-1 U.S. Atomic Clock in Boulder, Colorado. Our extraordinary new Stauer EMC^2 watch uses this clock to report the exact time from this remarkable cesium fission clock. So you are on time…all the time. This amazing timepiece will gain or lose only one second over a twenty million-year period. It is that accurate!

This perfectly tuned technological invention is now available for UNDER $100. And you'll never have to set this watch…the hands set themselves. Just push one of the buttons and you are synchronized with the F-1 and the hands of the watch move to the exact time position. The Stauer EMC^2 exceeds the accuracy of any Swiss luxury automatic so you can be more accurate and keep most of your money in your wallet… not on your wrist.

There are some unattractive plastic digital atomic watches on the market, but when our German movement maker made it possible for us to break the $100 price barrier with a beautiful, classically styled stainless steel analog watch, we were truly excited.

The operation of atomic precision depends on an electrical oscillator regulated by the natural vibration frequencies of an atomic system (as a beam of cesium atoms) accuracy to about one second in 20 million years, making it the most accurate clock ever made

The EMC^2 features precise atomic time with an automatic Standard time and Daylight Saving Time adjustment. It will adjust for leap years and even leap seconds! A breakthrough in technology at a breakthrough price.

The large numeric markers are luminescent and extremely easy to read so the watch is perfect for low light situation. The EMC^2 is water-resistant to 5 atms as well. The small readout shows you the date and has a digital second counter. This watch is rugged enough to take to the gym but handsome enough to wear to the boardroom or out to dinner. The designers built this watch for those who prefer their watches to be practical and sharp-looking rather than overrated and overpriced.

How can it be so accurate? The new F-1 clock uses laser beams to measure the photons emitted from the cesium atom to measure the resonance frequency. This laser-cooling clock makes it about 20 times more accurate than any other clock on earth.

This timepiece is a great gift for anyone who values precision and technology. Know precisely when the markets open and close. Know the times for landings and take offs or when the train is leaving the station. If punctuality and accuracy matter, then this watch was built for you.

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This watch is not available in stores and it comes with our 30 day money-back guarantee. If you're not completely satisfied with the accuracy, simply return the watch for the full purchase price.

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BRIEFLY NOTED

We Rode the Thunder—The Autobiography of the United States Air Force Thunderbirds

ed. by Bob Gore. M.T. Publishing, 2003. 200 pp., $44.95.

Once you get past the standard Air Force flag-waving and chest-thumping introductions, *We Rode the Thunder* offers former team members' unvarnished anecdotes with boys-will-be-boys titles like "Booger King," "Dead Ant," and the intriguing "Kaopectate and the Christ of the Andes." There are award-winning understatements: "The most exciting moment of the year was when Tony McPeak's wings came off while doing the bomb burst. He ejected, which means he landed without his airplane." (That's the Tony McPeak who, from 1990 to 1994, was known as General Merrill McPeak, Air Force Chief of Staff.) A former crew chief writes of the same incident: "Tony pulled up, and then both wings came off, followed by an enormous mushroom cloud." In the audience, a woman "was quiet for a second then said, 'That was added to the show recently.' "

—Patricia Trenner

Mars is calling. What are we waiting for?

The project Zubrin chronicles in *Mars on Earth*, his fifth book, arose partly from that impatience. With no nation making even the slightest move toward a real Mars expedition in the late 1990s, he and his Mars Society colleagues decided to set up their own "Mars habitat" on Canada's remote Devon Island, near a crater NASA sometimes uses as a surrogate for other planets' landscapes. He scratched together funds from media sponsors like the Discovery Channel and from assorted rich folks (including one who wrote a check for $100,000 after Zubrin promised, and delivered, a dinner with Buzz Aldrin). And so was born Robert's Excellent Adventure in the faux Martian wastelands of the Arctic (officially: Flashline Station).

As he narrates the experience on Devon Island, Zubrin never stops believing in the importance of this enterprise, even when finances threaten to fall through, or the walls of the habitat don't go up as planned. Contrasting himself with an engineer colleague, he says, "I'm a short, mercuric, optimistic romantic; he's a tall, phlegmatic, pessimistic existentialist. My favorite movie is *Casablanca*, his is *Brazil*."

Admirable as the scrappiness can be, it's sometimes hard to keep a straight face while reading overly detailed accounts of what was, after all, an elaborate exercise in playacting. At times I worried that the author would list every person he met and every video he watched during the three years of the project. Worse are the photos: Zubrin and company wearing fake spacesuits and helmets, zooming around in all-terrain vehicles while reporters and TV crews record the action.

Pretending probably won't get us to Mars. Zubrin's brand of romantic optimism might. It depends on whether you like *Casablanca* or *Brazil*.

—Tony Reichhardt is Air & Space/ Smithsonian*'s consulting editor.*

The Dream of Civilized Warfare

by Linda R. Robertson. University of Minnesota Press, 2003. 481 pp., $35.95.

Few books about U.S. air power devote many words to World War I—probably because, as author Linda R. Robertson mentions three times in her first four pages, back then "the United States did not have an air force and had no idea how to build one."

The Dream of Civilized Warfare looks at images in modern media, the propaganda techniques developed along with military aviation, and how those images stay with us—a point reinforced by President Bush's decision to don a flightsuit and land on an aircraft carrier.

Robertson, a professor of media and society at Hobart and William Smith Colleges in New York, covers a wide variety of cultural and political materials to show how legends of the ace evolved. In 1916, Woodrow Wilson noted that down on the ground, war had lost much of its "charm." Things like trench warfare and poisonous gases, he said, "detract alike from the excitement and the tolerance of modern conflict." Something was needed to distract people from the trenches.

The answer, Robertson points out, was to glorify the air war, where a pilot became a "winged Galahad," riding to fight in "a deadly and gallant tournament…far above the ruck and reek of war." This mythical image made it possible to overlook air combat's "high mortality rates, and the high rates of psychological breakdown."

Robertson writes clearly and well, although she repeats herself far too often. She includes short, vivid portraits of fighter pilots such as Eddie Rickenbacker and Canadian Billy Bishop (with 72 kills, "the single most decorated soldier in the [WWI] Allied Forces"). The book also examines two noted battle deaths, those of Theodore Roosevelt's youngest son, Quentin, and "the Red Baron," Manfred von Richthofen.

An epilogue describes how after World War I, leaders realized that "future wars would be determined by the bombing of cities," and looks at U.S. air power in the wars in Serbia, Afghanistan, and Iraq.

—Richard Sassaman contributes frequently from Bar Harbor, Maine.

FLIGHT SIMULATOR

Lock On: Modern Air Combat

Ubisoft, 2003. $39.99.

Lock On fills a place on game store shelves left vacant years ago by *Falcon 4.0* and the *Jane's* sims. It puts you in the F-15C, the A-10, and six Russian aircraft, including the MiG-29, and models their cockpits and systems to the last toggle switch and radar mode. It's possible to fly cooperative and competitive missions with other players online, and to design your own scenarios. Just don't expect to leap into the cockpit and start shooting—you'll need to put in hours of reading and training first.

Lock On's graphics are breathtaking. Cockpits are almost photographic, and details, like the glints of light on canopy scratches or the bullet holes on a battle-damaged A-10, are typical of the game's visual fidelity.

Unfortunately, the initial release is so buggy and crash-prone it is almost unplayable, but free downloadable patches from Ubisoft save the day. The printed manual is a scant 50 pages (a longer one is hidden on the CD). Unacceptable load times of two minutes are common, and the game's stated minimum system requirements are a tad optimistic. It may run on an 800-megahertz Pentium III, but with all graphics options switched on, it taxes a machine that is three times faster.

Game developers have long struggled to find the balance between pleasing flight sim purists, who embrace complexity, and the average player, who simply wants a few hours of aerial action. Omit a well-devised learning curve and even the most committed player will struggle to enjoy the game. *Lock On* will delight aficionados, but despite many virtues, it is not a game for everyone.

—Matthew Stibbe

Smithsonian
National Air and Space Museum

— Jon Reynolds, Brigadier General, USAF (Ret.) in front of one of his favorite planes in the Smithsonian collection, the F-100D Super Sabre. The aircraft is presently kept at the Paul E. Garber Preservation, Restoration, and Storage Facility in Suitland, Maryland.

PHOTO: ERIC LONG

"All these aircraft set every milestone in aerospace history..."

"Thirty-one years in the Air Force gave me many great opportunities. I flew several memorable aircraft including the F-100, the F-105, and even a MiG-17 when I was stationed in China as Defense Attaché."

His first opportunity was at age 12, when Jon Reynolds flew in a float plane off a lake in Canada. Hooked on flying, he went on to an extraordinary career. He's a pilot with two combat tours in Vietnam, a retired Air Force Brigadier General, a professor with a Ph.D. in history who taught at the Air Force Academy, and a Board member of the National Air and Space Museum.

Jon Reynolds and his wife, Emilee, have also taken the opportunity to make the National Air and Space Museum beneficiary of a generous trust. They are now members of the *Smithsonian Legacy Society.*

Find out how you can include the National Air and Space Museum in your estate plans. Fill out and return the reply form below, or call 202-633-2602. You may also e-mail legacy@nasm.si.edu. Additional information can be found at **www.nasm.gift-planning.org.** Continue the opportunity for everyone!

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A&S 07-04

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CREDITS

"That's Why We Fly." Terry Burlison is a writer and aerospace consultant in Seattle.

Shop Talk. After all these years, O.H. Billmann's mouth still waters whenever he sees a spark plug.

The People and Planes of Spruce Creek. Debbie Gary lives with her Super Cub and Marchetti on a tiny airpark in Texas.

Photographer Cameron Davidson shoots from aboard helicopters, jets, tail-draggers, and hot-air balloons. He is still waiting for the perfect blimp shot.

The First 1,000 Days. Thomas D. Jones, planetary scientist, author, and speaker, spent 53 days in orbit as a shuttle astronaut. He is co-author, with Michael Benson, of *The Complete Idiot's Guide to NASA*. Jones' next book, *Space Station Odyssey*, will be published this year by Smithsonian Institution Press.

The 30 Billion Dollar Man. Bill Sweetman is a frequent contributor to *Air & Space/Smithsonian*.

The Hotrod Squad. Graham Chandler writes from Calgary, Alberta, Canada, not far from the Cold Lake air base where he flew as a test engineer.

How Things Work: Safer Fuel Tanks. Damond Benningfield, a freelance aviation and space writer in Austin, Texas, writes and produces the nationally syndicated radio series StarDate.

Saturn's Deep, Dark Secret. Craig Mellow is a freelance journalist who, after living many years in Europe, now lives in New York.

Origin of the Species: Bell XV-3 Tilt-rotor. The author of 33 aviation books, Jay Miller is a retired aviation museum director in Fort Worth, Texas.

First Church of Combustion. *Air & Space* editor George C. Larson attended an advanced pilot seminar session in March 2003 and is now a believer.

All Guts, No Glory. James L. Noles, Jr., is an attorney in Birmingham, Alabama, where he practices environmental law. A graduate of the United States Military Academy in West Point, New York, his most recent book is *Twenty-Three Minutes to Eternity: The Final Voyage of the Escort Carrier USS* Liscome Bay.

CALENDAR

June 1
Aircraft Owners and Pilots Association Fly-In and Open House. AOPA Headquarters, Frederick Municipal Airport, MD, (301) 695-2159.

June 1–13
Hubble Space Telescope: New Views of the Universe. An exhibit from the Smithsonian Institution Traveling Exhibition Service, featuring hundreds of Hubble images. Air Zoo, Kalamazoo, MI, (866) 524-7966.

June 4–6
Bellanca-Champion Club West Coast Fly-In. Columbia, CA, (518) 731-6800, *www.bellanca-championclub.com*.

June 5
A Remembrance of War Seminar Series: "A View From the Smithsonian." Don Lopez, former World War II ace fighter pilot and now assistant director of the Smithsonian Institution's National Air and Space Museum, discusses his lifelong love affair with aviation. American Airpower Heritage Museum, Commemorative Air Force Headquarters, Midland, TX, (432) 563-1000, ext. 2259, *www.commemorativeairforce.org*.

June 6 & July 4
Open house at the only restored Nike missile site in the United States. Fort Barry, Sausalito, CA, (415) 331-1453, *www.nikemissile.net*.

June 12 & 13
Wings 'n Wheels. Air and military vehicle show. St. Lucie County International Airport, Ft. Pierce, FL, (800) 804-5445, *www.slcwingsandwheels.com*.

June 18–20
Gathering of Warbirds Airshow. Olympic Flight Museum, Olympia Regional Airport, WA, (360) 705-3925, *www.olympicflightmuseum.com*.

Golden West EAA Fly-In and Airshow. Marysville, CA, (530) 741-6463, *goldenwestflyin.org*.

June 26 & 27
New Mexico Scale Association All-Scale Radio-Control Fly-In. Maloof Memorial Airpark, Albuquerque, NM, (800) 224-4202.

July 9–11
Gathering of Eagles Airshow. Ashtabula County Airport, Jefferson, OH, (216) 587-4027.

July 10 & 11
History of Flight Airshow. Geneseo Airport, NY, (585) 243-2100, *www.1941hag.org*.

Organizations wishing to have events published in Calendar should fax press releases two months in advance to (202) 275-1886 or mail them to Calendar, Air & Space/Smithsonian, *MRC 951, P.O. Box 37012, Washington, DC 20013-7012.*

FORECAST

In the Wings...

XAVIER MEAL

Lord of the airshow: A Lavochkin La-9 starred in New Zealand.

Warbirds Over Wanaka

New Zealand's famous airshow delivered another weekend packed with rare and famous military aircraft, not to mention the spectacular scenery of Middle Earth.

Catcher in the Sky

A helicopter pilot will make the catch of his life this fall: A spacecraft returning from a million miles away must be snagged by the scruff of its parachute.

Are Two Better Than One?

Two-part quiz: (1) What do the P-38 Lightning, OV-10 Bronco, and Burt Rutan's *Voyager* have in common? That was the easy part. (2) Why were they designed that way?

ON THE WEB SITE

www.airspacemag.com

CHAD SLATTERY

A formation of A-4s hangs in the National Museum of Naval Aviation in Pensacola, Florida.

Of the many colors worn by the Douglas A-4 Skyhawk (see "The Hotrod Squad," p. 40), the jazziest are the blue and gold of the U.S. Navy's Blue Angels. Visit the Web site to see a gallery of the aircraft that have flown in dress Blues and to learn more about A-4 designer Ed Heinemann.

Also: Link to sites tracking the Cassini spacecraft (see "Saturn's Deep, Dark Secret," p. 50) as it makes its way toward Saturn and its mysterious moon.

TERRY HALLET

Jon Jacobs (left) and NAA observer Steve Gigax go over Jacobs' Mitchell Wing b-10 ultralight, which stayed aloft for 171 miles to set a distance record.

The Best of 2003

The National Aeronautic Association, the nation's official keeper of aviation records, cited eight records as the most impressive feats of 2003, three of which are noted here.

On December 5, Gulfstream Aerospace dispatched a G550 business jet from its Savannah, Georgia, plant to Dubai, United Arab Emirates. Pilots William Watters, Raymond Wellington, and Ahmed Ragheb completed the trip in 13 hours and 44 minutes, covering 7,546 miles, a world record in the G550's weight class for distance without landing. Takeoff weight was 91,000 pounds, nearly half of which was fuel.

Jon Jacobs challenged a distance record on November 30 in a Mitchell Wing b-10 ultralight. With the help of a tailwind, he managed to stay aloft for 171 miles, flying from Burnettsville, Indiana, to Petersburg, Michigan. Jacobs set a world record for distance in a straight line with limited fuel in the ultralight category, besting a record that had stood for 15 years. Under NAA rules, Jacobs could take off with only 2.7 gallons of fuel. After his flight, he discovered the tank still had fuel. "I was dumbfounded," he says. "I had flown 171 statute miles on only 2.2 gallons of fuel. That is 77.72 miles per gallon, at an average speed of 72.25 miles an hour. Not bad for a 20-year-old ultralight with a 44-year-old engine."

Randolph Pentel and Mark Anderson opted for the fastest time to fly around the border of the continental United States—and arranged with the U.S. Marine Corps to promote the Toys for Tots Christmas program en route. Accompanied by an NAA observer and three passengers, the two professional pilots took off from International Falls, Minnesota, on December 15 in a Cessna Citation Ultra business jet and headed west along the Canadian border. Their first stop was Boeing Field in Seattle. After a few hours of sleep, they flew down the west coast to San Diego, then turned east, along the Mexican border, and landed in Yuma, Arizona, Brownsville, Texas, and Fort Lauderdale, Florida, before taking another rest. On December 17, they flew up the East Coast to Norfolk, Virginia, achieving their goal of crossing over Kitty Hawk, North Carolina, to honor the centennial of flight below. They headed for Maine, then landed at Niagara Falls, and flew over the Great Lakes to their starting point. Total time: 45 hours and 27 minutes, a new record. Distance: 9,618 miles. Toys distributed: over 100.

—Stuart Nixon

Moments & Milestones is produced in association with the National Aeronautic Association. Visit the NAA Web site at www.naa-usa.org *or call (703) 527-0226.*

LOGBOOK

Awards

Air Force Unit "Vijay 10" won the 2003 **Mackay Trophy**. The five-member crew planned and led a key portion of Operation Northern Delay in Iraq, the main supporting action for Operation Iraqi Freedom. On March 26, the first night of the coalition ground campaign in northern Iraq, the crew directed the combat insertion of the 173rd Airborne Brigade with a 15-ship formation of C-17A Globemaster III strategic transports.

Richard Abruzzo was awarded the **Harmon Aeronaut Trophy** for his balloon flight from San Diego, California, to Waverly, Georgia. The 2,074-mile flight also set a distance record for his gas balloon's class and size (AA-6), breaking a record set in 1983.

The **Frank G. Brewer Trophy** for aerospace education was awarded to Phillip Woodruff for nearly 40 years of work in promoting aviation programs. Woodruff, 59, a senior manager with the Federal Aviation Administration in Washington, D.C., has also held posts related to aviation education with the U.S. Air Force and Cessna Aircraft Company.

The 2003 **Collier Trophy** was awarded to the Gulfstream G550 team for developing an ultra-long-range business jet that includes numerous technological and safety advances. Gulfstream Aerospace partnered with Honeywell International, Kollsman, Rolls-Royce, and Vought Aircraft Industries to build the G550.

Nominations

Nominations will be accepted for the 2004 Frank G. Brewer Trophy from September 1 until November 30. The trophy is awarded annually to an individual, a group, or an organization for significant contributions of enduring value to aerospace education in the United States.